Lorenzo Guasti, Beatrice Miotti

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PREFACE

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In this book we will study, through papers, how Schools are leading advancements in Makerspaces, Robotics, AI, and Coding.

The field of education is experiencing an exciting scientific renaissance. Schools around the world have embraced emerging technologies and hands-on learning approaches that are fueling advancements in areas like robotics, artificial intelligence, and computer programming. We are also finding a lot of scholastic makerspaces that are driving the change of the idea of laboratory teaching. The research studies and projects featured in this volume provide a glimpse into how schools are leading innovation at the cutting edge of science and technology.

The contributions we received highlight just how relevant and important these topics are to schools today and in the coming years. For example, several studies explore how makerspaces - creative, DIY spaces for building and tinkering - can boost student engagement and interest in STEM. Others show how robotics competitions are inspiring students to pursue advanced skills in engineering, team work and coding. Several fascinating projects demonstrate how students are applying machine learning and AI to solve complex real-world problems. And researchers are finding that project-based coding courses can open students' eyes to the power and possibility of software and web development.

These areas represent an exciting scientific frontier that schools are exploring. The research and initiatives featured in the papers contained in this book demonstrate how robotics, AI, coding, and other technologies are transforming learning and empowering students and teachers alike. While still emerging, these topics are poised to shape the future of education in the years to come. Schools that foster innovation in these areas will be at the forefront of advancements that drive lifelong learning and success in our increasingly digital and automated world.

Teachers and educational experts have long been advocating for an education model that focuses on students and hands-on learning experiences rather than traditional didactic instruction (Dewey, 1902; Montessori, 1965). The teaching approach underlying all of the research presented here is undoubtedly centered on constructionism as articulated by Papert (1980) and later by Blikstein (2018). This approach shares constructivism's view that students should be the focus of their own learning, with teachers facilitating students' self-guided work. However, constructionism takes these ideas further by having students create tangible objects instead of purely theoretical or conceptual ones. Students make things that operate in the real world, and that can be physically built, manipulated, and continually improved.

Researchers at this conference have written papers that go deep into these topics like hands-on activities, student-driven, product-centered studies. Their work taps into students' inherent interest in creating personally meaningful projects that produce concrete results, enabling deeper understanding and engagement. This approach, focused on constructing sharable artifacts, offers a powerful way to cultivate students' interest and fluency in science, technology, engineering and math.

The constructionist framework underpinning these contributions points to an exciting direction for the future of education. By giving students opportunities to create and build in collaborative makerspaces, develop and program functioning robots, train machine learning models to solve problems, and code applications that others can use, schools can transform learning into an active process of discovery and invention. Students become the designers, builders and creators of tomorrow's innovations.

Overall, the contributions we received reveal how schools are leading the way in applying new technologies and hands-on techniques to prepare students for the future. This book provides a glimpse into the great scientific promise these areas hold to enhance learning, accelerate discovery, and drive progress in schools. The future is bright, and these topics will only become more integral to education over time. Schools and students have the opportunity to be pioneers at the cutting edge of fields that will define the careers and disciplines of tomorrow.

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MAKERS PEDAGOGY

Makerspace and Fablab at school: realizing a maker approach to teaching and learning, new models, emerging methods and instruments.

Robotics for everyone: an experience of Educational Robotics and Coding for differently skillful pupils

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ABSTRACT

The paper reports a laboratory experience on Education Robotics and Coding, which was specifically targeted to differently skillful pupils of middle school. The project consisted of three main stages; i) coding unplugged; ii) building a small robot; iii) coding the robots. The lab team was composed of 10 pupils, including tutor pupils, and special-needs teachers. Qualitative observations showed that Educational Robotics and Coding activities may help differently skillful pupils to improve involvement, attention, and socialization.

Keywords

Educational Robotics; Coding; Differently Skillful Pupils; Middle School; Lego Wedo

1. CONTEXT AND OBJECTIVES

Educational Robotics and Coding can be a powerful tool to achieve pedagogical objectives in differently skillful pupils, such as: (i) encouraging learning processes; (ii) encouraging the acquisition of basic autonomy; (iii) helping to improve motivation and self-esteem; (iv) mastering psychomotor procedures (sense-perceptual, manipulation, manual skills, spatio-temporal orientation and motor coordination) (v) encouraging social inclusion.

We introduced Educational Robotics and Coding as an extra-curricular activity involving pupils of middle school (age 11-13), including differently skillful pupils, with the main objective of developing cognitive skills such as operational autonomy, attention, concentration, and motivation. The activities were aimed at stimulating curiosity and involvement in the proposed tasks, which required to analyze and solve problems, by using a graphical programming language and physical robots. All the tasks were accomplished through a learn-by-doing methodology and a peer-to-peer approach with pupils of different skills.

In the subsequent Section, a detailed description of the activities is reported. In Sect. 3, some observed results are commented. Finally, Sect. 4 reports broader comments on the reached objectives and suggestions for future activities.

2. DESCRIPTION

2.1. The project "Robotica per tutti" (Robotics for everyone)

The project has been implemented in a Middle School located in Apulia, Italy. It consisted of 10 hours of activities, subdivided in five days. A total of 10 pupils have been involved, including five differently skillful pupils, and the remaining acting as "tutors". Age group was 11-13 years old. The activities were carried out in a specific lab, provided with PCs, interactive whiteboard (LIM) and a shared central table around which all pupils could perform their task by using robotics kits (Lego Wedo, Lego Wedo 2.0). PCs were equipped with Lego Wedo software for coding. All the special-needs teachers of the differently skillful pupils were also involved in the activities, one of them acting as a coordinator.

No previous experience was required by both pupils and teachers, in order to participate in the activities of the project. The coordinator was experienced in educational robotics and coding.

3. DESCRIPTION OF THE EDUCATIONAL EXPERIENCE

The project was implemented in three main stages, which are described in the following subsections.

3.1. Coding unplugged

The first stage was preliminary and aimed at teaching the basic principles of coding. It involved "coding unplugged" activities through the "pixel-art" technique: a program was available with directions to draw each pupil's name and class, which was eventually colored on a paper grid. The tutor pupil followed the other pupil work, possibly suggesting corrections and giving help.

At the end of the activity, the pupils were stimulated by teachers in discussing their achievements, with the specific aim at showing the importance of following the coding rules to achieve a correct result.

Figure 1: Coding unplugged with pixel-art

3.2. Building a small robot

The second stage was aimed at applying the principles of coding to build small robots with different complexity levels in accordance with the skills of pupils. First, the coordinator illustrated the general procedure for building a robot by using the software available to the pupils. The differently skillful pupils chose their preferred robot (possibly with the guidance of their teachers) and built their physical robots by following the instructions presented by the software and guided by their tutors. Examples of built robots are: crocodile, bird, earthquake simulator. All robots were equipped with sensors (e.g., proximity sensors, light sensors, etc.) and effectors (motors in particular) in order to show a dynamical behavior so as to stimulate curiosity and motivation.

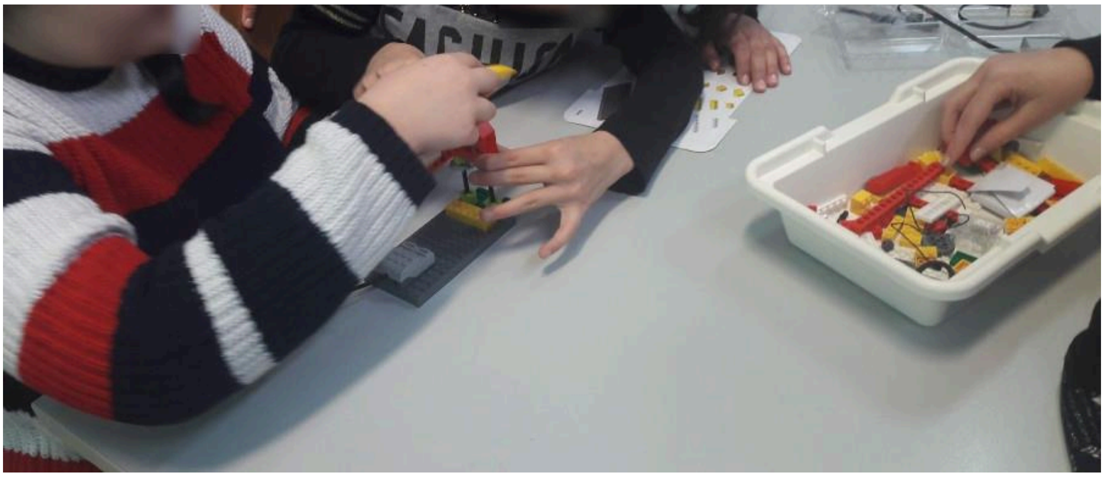

Figure 2: Building a bird robot

3.3. Coding the robots

The last stage was aimed at programming the robots in order to provide them with the ability of responding to external inputs. The didactic objective was to learn how following a correct procedure leads to a desired behavior of the robot. Before starting to code, the coordinator illustrated the visual coding language provided by the software. The software showed the coding solution, and the pupils were asked to reproduce the solution by using the proper coding blocks. Then, the pupils could test their code on the robot and eventually change some of the program parameters (e.g., sound effects, rotation direction and speed, etc.) in order to observe the effects. The tutor pupils supervised the coding process and suggested possible parameter valorization to customize the behavior of the robots. Teachers supervised the whole work. Trial-and-error was a particularly effective approach in this stage, because errors and undesired behavior stimulated the pupils in finding mistakes and eventually correcting them. At this stage, the role of tutor pupils was fundamental in detecting errors and suggesting solutions.

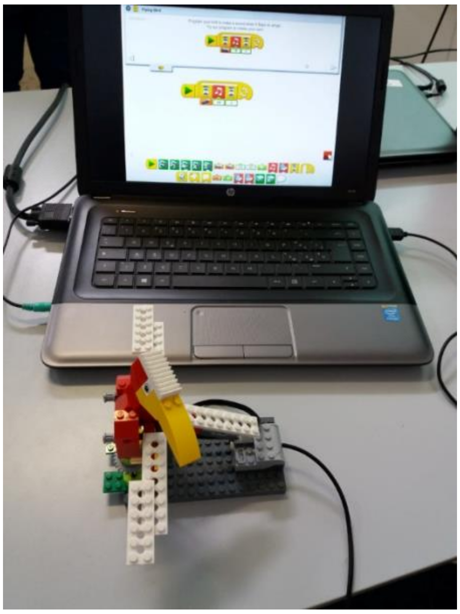

Figure 3: Coding the bird-robot

4. OBSERVATIONS

The project involved five differently skillful pupils, which are here identified as S1, S2, …, S5. We observed the behavior of the pupils and their reaction to all the developed activities. Following is a synthetic description of the observations.

Table 1. Observations of differently skillful pupils in the project activities

Pupil	Diagnosis	Symptoms	Observation
S1	ADHD	Impulsivity, inattention	The pupil was highly attracted at the involved tasks, especially in the coding unplugged. He/she waited his/her turn in building the robot and in its coding.
S2, S3	Mental impairment (not severe)	Reduced concentration ability	The pupils were able to follow the instructions to build the robot from beginning to end. They were able to build the most complex robot (earthquake simulator).
S4	Mental impairment (severe)	Severe socialization difficulty, impulsivity	Thanks to the guidance of the tutor pupil and the teacher, the pupil was able to build the robot by controlling his/her impulsivity and putting himself/herself in relation with the tutor pupil and the teacher.

S5	Autism	Verbal impulsivity, reduced concentration	The pupil was able to focus on all the activities; verbal impulsivity was greatly limited. The tutor pupil was fundamental to give positive emotional feedback to the pupil.

5. CONCLUSION

5.1. Results

The pupils were exposed to new, stimulating activities that fall outside the usual activities carried out during teaching classes. They were able to exert psychomotor procedures, including manipulation, spatio-temporal orientation and motor coordination. Furthermore, they had the opportunity of working in a team so that they were encouraged in social interactions. The pupils were asked to solve simple problems by using tools (both hardware and software) that stimulated their curiosity. Consequently, notwithstanding severe symptoms of impulsivity, reduced concentration and inattention, the pupils were able to follow the instructions and to focus on the assigned tasks either in autonomy or with the aid of the tutor pupils. Tutor pupils were able to learn the fundamentals of coding (both unplugged and in software) and received a significant inclusion experience.

The observed behavior was relatively unexpected to the teachers, because concentration, socialization and self-control were rarely observed in traditional classes. In particular, the manipulation tasks were especially attention-absorbing and significantly helped pupils in containing their symptoms. These results suggest a higher number of hours to be devoted to such activities in future editions of the project. Furthermore, increasing levels of complexity could be imagined, so as to further stimulate pupils' imagination, manipulation and socialization. It is expected that, if these practical activities are included in traditional classes, the symptoms of differently skillful pupils may be significantly contained on a daily basis.

5.2. Broader Value

The reported experience clearly shows that Educational Robotics and Coding are excellent tools for empowering inclusion of differently skillful pupils: the playful aspects of some educational kits (e.g., Lego WeDo), the ability of building complete robots from scratch and the possibility of endowing them with customized, programmable behavior, strongly attracts the attention of pupils, even with severe mental impairment, so that some symptoms are significantly contained. Consequently, these tools can be effectively used in classrooms, also involving differently skillful pupils, to enhance social interaction and sharing of tasks and goals.

The complexity level of the adopted kits was adequate to all the involved pupils. However, in case of pupils with more severe impairments, robots that do not require to be preliminarily built (e.g., Bee Bot, Cubetto) may be more appropriate. The activities proposed in this project were planned according to the experience of the involved teachers; however, a platform for special-needs teachers that is specifically aimed at sharing experiences and best-practices for using Educational Robotics and Coding for differently skillful pupils, could promote the application of this methodology to a broader base of pupils and students.

5.3. Relevance to Theme

The reported experience lies at the intersection of Education Robotics and Coding on one side, and special needs and inclusion in education on the other side. The methodological tools of special-needs teacher require a continuous evolution in order to make School a place for everyone by unlocking the potential of all pupils in a context of togetherness.

Figure 4: Robotics is for everyone!

BIOS

Laura Cusanno is a special-needs teacher (middle-school) and "digital animator" of the "I.C. BATTISTI-GIOVANNI XXIII" Corato, an Apulian city close to Bari. Within her teaching job, she gained experience in Educational Robotics, Coding and educational methodologies involving digital technologies like Augmented Reality and Gamification. Her special focus is on improving inclusiveness of differently skillful pupils by using digital solutions.

3D School

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ABSTRACT

I'm a technology teacher in a public secondary school in Genova (Italy). My school is located in a highly multicultural suburban context and my students are aged between 11 and 14.

The "3D school" project that I present below is an educational 3D printing project carried out during the last school year and successfully presented at the National Digital School Award in Italy. Year after year I am more and more convinced that, citing the famous volume by S.L. Martinez and G. Stager, "invent to learn" and you do it better if you do it together with others.

KEYWORDS

3d model; 3d print; art; graphics; collaboration; school belonging; inclusion; making; video-making; digital artisans; craftsmen

1. DESCRIPTION

1.1. Description of your setting

I teach technology in the "A. Volta "in Genoa for six years. Ours is a suburban school attended by approximately 300 children aged between 11 and 14. One of the main characteristics of the school is its multiculturalism welcoming children from all over the world (South America, North Africa and Central Africa, China, etc…). Pupils often live in culturally and economically poor family contexts and find in the school a great opportunity for redemption.

I always give my lessons in a smart laboratory equipped with material for making, coding, tinkering and robotics activities and I often collaborate with other teachers trying to develop an effective and engaging STEAM teaching.

1.2. Description of the educational experience

The main goal of the "3D School" project is to involve pupils in the customization of school spaces through the design of objects printed with a 3D printer, with a view to developing digital creativity thanks to the tools of three-dimensional modeling. The project is part of the disciplines attributable to the acronym STEAM (Science, Technology, Engineering, Arts, Mathematics) with the aim of integrating artistic and technical activities through a laboratory approach typical of making aimed at developing an innovative and inclusive teaching of "digital manufacturing". In particular, a reality task was proposed to the students that saw them take on the role of graphic designers and "digital artisans" who were asked to design the new classroom signs and logos of our institute laboratories; a sort of coordinated 3D image of the school. The students first produced some preparatory sketches on paper and carried out research work on the Thingiverse and Thenounproject platforms, real "open source" containers of graphics and 3D printing. Then they experimented with digital drawing and three-dimensional modeling using the "SketchUp" software and finally they deepened the passage from virtual design to the realization of the concrete product through the slicing software "Cura". The cooperative learning activities were conducted for small work groups to each of which was assigned one or more spaces / classes for which to design the logo / sign.

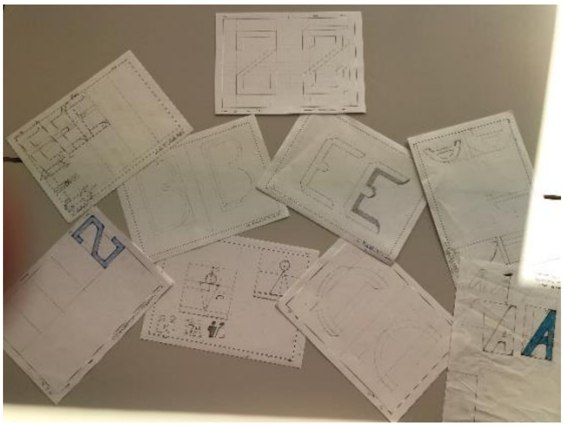

Figure 1. Sketches

Figure 2. Science Lab DNA Logo

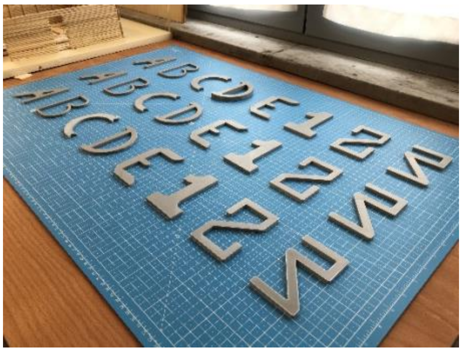

Figure 3. Letters and numbers for classes

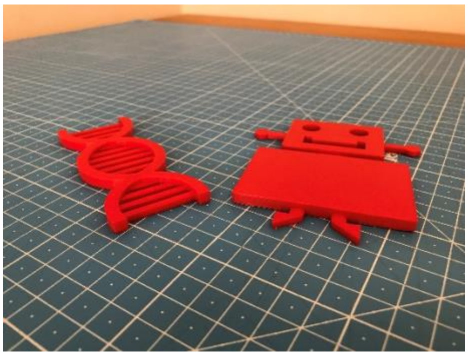

Figure 4. Logos

Below is the link to the video presentation of the Italian Digital School National Award https://drive.google.com/file/d/1qnWrfcpTvCljotI9FWqGuB7SjUPoR2NV/view?usp=sharing

2. CONCLUSION

2.1. Results

The project aimed to develop the knowledge and use of software dedicated to technical drawing and three-dimensional modeling (SketchUp and Cura). These tools allowed students to develop their creativity with more complex results than they could have achieved with hand drawing. Furthermore, particular attention was paid to the management and sharing of the files produced through the G-Suite for Education, accustoming the students to archive the material produced on the network to make it accessible from any device and to work in sharing with classmates, simulating a real work context. It was interesting to see the enthusiasm of the students seeing the product they designed digitally created: the students have become "digital artisans". For someone of them the didactic activity was important for them in terms of scholastic orientation in view of the choice of the future course of study.

2.2. Broader Value

What can be learned from your experience and its value for other educators? What is the value from what you learned to the maker-centered/hands-on/digital fabrication learning communities? What is the key learning that you will share with the broader community at FabLearn?

“Invent to learn” is the guideline of my teaching activity and I would like to communicate how important it is to stimulate creativity in children also in the technical-scientific field, overcoming barriers of gender, age, nationality. Another key value that I experienced during this activity is that the real formative evaluation is the one that the teacher provides during the activity with his continuous feedbacks and not the rigid and not inclusive one represented by tests or questions. I would like to share the good fortune that I have as a teacher learning with my students in the laboratory because their questions, their requests for help stimulate me to research and experiment new solutions and sometimes unexplored worlds. Maker-centered / hands-on / digital fabrication learning communities want fun and learning to coexist as opposed to the traditional school model that keeps them rigidly separate.

2.3. Relevance to Theme

I think that the project I present is an example of what Makerspace and Fablab at school could mean: simultaneously developing digital and manual skills; artistic and technical-scientific skills without that rigid distinction in too many singular subjects that italian secondary school has not yet decided to eliminate.

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Evaluation of digital fabrication projects in school: Available tools and value-added of using impact evaluation methods

Martina F. Ferracane[a], Adriano De Falco[b]

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[b] EUI

1. INTRODUCTION

In recent years we have witnessed an increase in digital fabrication projects in schools, both as a curricular and, more often, an extra-curricular activity. While these projects are generally considered to generate a positive impact on students by raising their interest in STEM subjects, little empirical evidence exists on their effects other than general anecdotal evidence. Evidence of the effects of digital fabrication projects can be gathered in different ways. On one hand, robust impact evaluation methods, which include experimental and quasi-experimental methods, represent the main tools to evaluate the impact of these projects. Among these approaches, the randomised controlled trials (RCTs) are considered best practice for rigorous educational evaluation.

When impact evaluation methods are not feasible, other evaluation methods can prove a valuable instrument to gather evidence and identify best practises. This is not only important for the evaluation of a specific program, but especially important to support the design of future programs and projects. In this paper, we present an overview of the assessment tools that can be used to evaluate digital fabrication projects in school. We start by presenting more general methods for evaluation that can be used in virtually all school projects (Section 1) and then move to present the main impact evaluation methods (Section 2). Throughout this paper, we leverage on the experience of the Fabschool project to present practical examples of how these tools can be used.[1]

1.1. General instruments for project evaluation

A variety of qualitative and quantitative tools can be used to conduct a project evaluation. They represent a valuable instrument to gather evidence from digital fabrication programs and to identify best practises. These tools represent a viable option when impact evaluation methods are not feasible, but also in combination with them. The most common examples include surveys, interviews, observations, and focus groups.

1.2. Surveys

Surveys can be used to collect information from large numbers of people before, during, or after the project. Their benefit lies in their capacity to collect specific and comparable information from a potentially large group of individuals in a short time. Yet, the information might be superficial, especially if the questions are not well designed, and the analysis of open questions can be time-consuming.

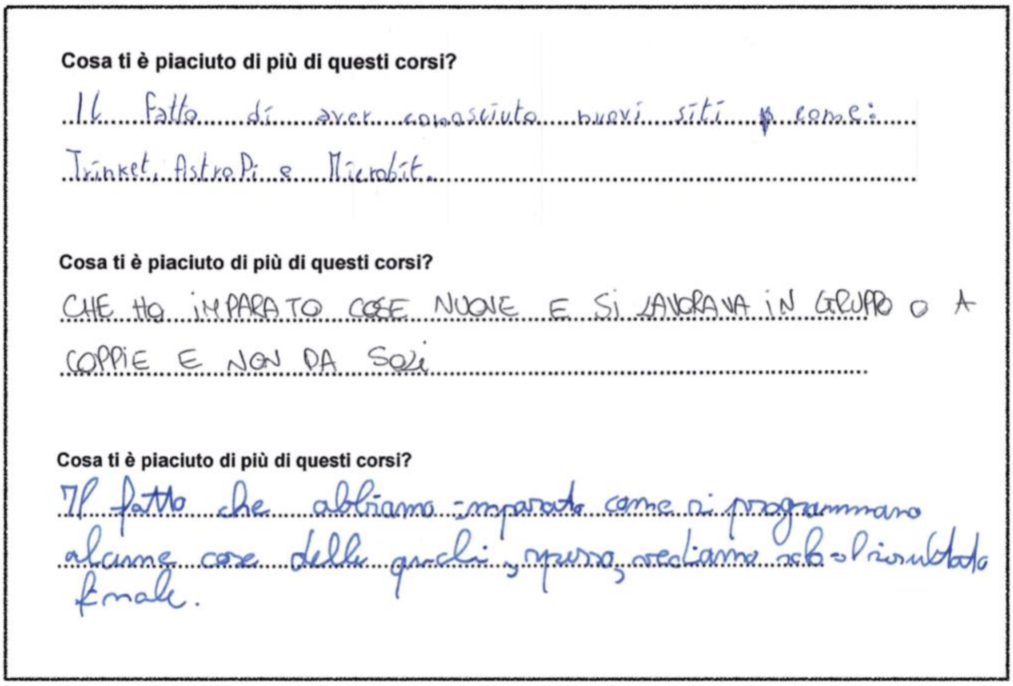
In the case of school projects, surveys could be used in different ways and for different objectives. For example, the same questions could be asked at the beginning and at the end of a project to identify whether there have been changes in the responses.[2] They could also be used during the project to gather feedback from the students

[1] Fabschool is a project run by Fondazione Edulife, which brings together FabLabs in different regions of Italy to create spaces dedicated to creative digital education in schools. More information can be found at this website: https://www.fabschool.it/fabschool/

[2] However, as explained in Section 1.5, these results can only be interpreted as anecdotal evidence and not as a direct effect of the activities.

and try to correct flaws while the project is still ongoing. Additionally, they could be administered immediately after the project to get feedback and to gather students' preferences for future activities.

Examples of the questions that have been asked of students as part of the Fabschool project are: which aspects of the course they liked the most, what they think can be improved, and what activities they would like to attend in the future. Figure 1 shows some of the answers provided by primary school students following a course on digital fabrication offered by FabLab Dolomiti. The answers provide interesting insights into different aspects that students consider valuable. Some students highlight the actual technical skills acquired (for example, being able to use Micro:bit or Astro Pi), while others point out that they especially appreciate the fact of being able to work in groups. Finally, some students consider it especially valuable being able to understand what is behind an IT solution of which they 'often only see the final result'.


Cosa ti è piaciuto di più di questi corsi?

Il fatto di aver conosciuto nuovi siti e come: Trinket, Astro Pi e Microbit

Cosa ti è piaciuto di più di questi corsi?

CHE HO IMPARATO COSE NUOVE E SI LAVORAVA IN GRUPPO O A COPPIE E NON DA SOLI

Cosa ti è piaciuto di più di questi corsi?

Il fatto che abbiamo imparato come si programmano alcune cose delle quali, spesso, vediamo solo il risultato finale.

Figure 1: Collecting students' feedback through surveys

Source: Fabschool course taught by FabLab Dolomiti in Sedico (BL), Italy.

1.3. Individual interviews

Individual interviews can take different forms, from unstructured conversations to in-depth interviews. They can be a valuable instrument throughout the project to identify needs, track changes, or seek feedback (Oxfam, 2007), but also to identify good practises. The content of the interview can run from more factual and straightforward questions to more sensitive and complex issues.

In a school context, the interviews could involve students, teachers, and trainers, but also parents and school principals. It is important that the people interviewed understand why the interview is being conducted and that, in the case of minors, parents are informed and have consented to the interview. As an example of the value added of interviews, as part of the Fabschool project, we were able to identify two important good practises that might have gone unnoticed if only surveys and empirical analysis were conducted.

By interviewing the trainer, we found out that the teachers were actively involved in the design of the course. This has resulted in higher engagement from the students as teachers were actively supporting the delivery of the course by the trainer. Another good practice we identified thanks to the interview is that one teacher connected the theme of the digital fabrication course with one of the subjects taught in school, raising in turn the interest of the students towards the subject. In this particular case, the digital fabrication course had as its subject creating a house for bees. The teacher prepared the students by teaching them what bees are, what their role is in our ecosystem, and which different flowers are related to pollination. The students used this knowledge first to create animations and games through Scratch, and then to build the bee house with Lego and sensors (Figure 2).

Figure 2: Connecting digital fabrication to school subjects

Source: Fabschool course taught by FabLab Dolomiti in Sedico (BL), Italy.

1.4. Observations

A project evaluation can also use observation of a specific setting as a source of data for the research. This methodology includes a continuum of observational practises, from strictly naturalistic observation to more involved participant observation (University of Manitoba, no date).

Participant observation is a research methodology where the researcher is immersed in the day-to-day activities of the participants. The researcher can take the role of a complete observer, a participant-as-observer (more observer than participant), an observer-as-participant (more participant than observer), or a complete participant. In the first case, the researcher has no contact with those she or he is observing, while in the latter case, the researcher would be wholly concealed from the participants. As might be expected, most research in practice falls between these two poles (Smith, 1997). Each of these situations can provide different insights to support the evaluation of the program.

In the school context, an observation could take different forms. It could go from shorter, more discrete sessions in certain classrooms, where the researcher has limited interaction with the teachers and students, to participant observation in which the researcher tends to be embedded in the school setting for an extended period of time, may even assist the teacher, and will interact with students and teachers to gain a better understanding of learning and teaching procedures (University of Manitoba, no date). In the case of short school projects, it could be an option for the researcher to attend some activities as a participant or an observer using this opportunity to learn about the specifics of the class or to identify students to interview at a later stage.

1.5. Focus groups

Focus groups represent an additional methodological instrument to use in project evaluations. They support discovering what interviewees think about a concrete theme in a situation in which they can contrast their opinions (Gil Flores and Granado Alonso, 1995).

A focus group brings together a group of people (ideally between 4 and 10 people) who do not know each other to discuss a particular topic proposed by the researcher. They are not about interviewing people, but about 'establishing and facilitating a discussion' (*Ibid.*). This instrument can generate hypotheses based on participants' ideas, collect exploratory data, evaluate different research contexts or people in the study, develop interview guides and surveys, interpret the results of studies, and achieve a deeper understanding of processes and outcomes (Morgan, 1998; Ansay *et al*., 2004).

In the context of a school project, the focus group could be used in the first phase of the study to collect general data about the context of the study, to generate hypotheses and to construct the questionnaires, including those that are used in the empirical research. For example, in the Fabschool project, focus groups have been leveraged to learn about student and teacher perspectives ahead of the project, to identify variables of interest to assess in the empirical investigation, and to formulate new entries for the questionnaires. In addition, they can be of great support at the end of the empirical analysis to interpret the results. As stated in Gil Flores and Granado Alonso (1995), 'focus groups can offer enlightenment'.

1.6. How to interpret insights from the general evaluation methods

While these instruments can be very valuable to gather information and, especially, to identify best practises and areas for improvement, their efficacy is limited when it comes to measuring the impact of the program.

To clarify this point, we can give an example. Consider that a new professor in a high school proposes an extra-curricular activity to her students. She sets up a course on 3D printing and offers all students the chance to enrol if they are interested. At the end of the course, she conducts surveys and finds that the majority of the students are more interested in STEM than students who did not join the courses. One might naively think that the course had a positive impact on the students' interest in STEM. However, this conclusion is flawed for different reasons.

The fact that students have chosen freely to enrol in the course shows that the students were already interested in the subject, so they were more likely to develop an interest in STEM (so called 'selection effect'). Therefore, comparing individuals who took the course with the ones who did not leads to misleading conclusions about its effect. Also, if we were to compare interest in STEM before and after the treatment for students who enrolled, there may be other factors, such as other courses taken by the students during curricular activities, the presence of a new professor, and other activities followed by the students, which could bias our results. These factors are usually referred to as 'confounding factors'.[3]

This simple example shows that the results of general project evaluation tools should be taken with a pinch of salt. They can point out interesting insights, but they cannot provide a measure of the efficacy of the project to achieve its expected outcome. The instruments that allow controlling for the selection effect and for the presence of confounding factors, and therefore allow the researcher to determine the 'causality' between the program and the change in the variable of interest, are referred to as impact evaluation methods. The main methods are summarised in the next section.

2. IMPACT EVALUATION METHODS

Impact evaluation methods are more resource-intense and can usually be undertaken only in more structured projects, which can rely on an external evaluator. These can complement a project evaluation by providing more insights on the 'causality' between the course and the change in the variable(s) of interest, and therefore represent the main instrument to assess the impact of the projects.

[3] For a detailed overview, see Angrist and Pischke (2015).

These methods rely on counterfactuals, that is they compare the outcomes of interest of those having benefited from a policy or programme with those of a group similar in all respects to the treatment group. Borrowing from medical terminology, the courses can be considered as ‘treatments’ and the students involved in the courses can be defined as ‘treated’ in contrast with the ‘non-treated’, or better, the ‘control group’, who are the students not joining the courses. The treatment is conducted with the objective to have an impact on the treated group and, therefore, the evaluation aims to assess whether the treatment has achieved its objective.

In this section, we present the main statistical tools that could be used for impact evaluation in the context of a school project. We start by introducing randomised experiments (RCTs), which are the gold standard for rigorous educational evaluation. RCTs are considered an experimental method as both the treatment and the control groups are selected randomly.

The rest of this section provides information on alternative instruments that can be used when the random selection of the two groups is not possible. These quasi-experimental methods include matched-comparison group design, regression-discontinuity design, instrumental variables, and difference-in-differences. These methods support the creation of comparable groups.

2.1. Randomised Controlled Trial

Randomised controlled trials (RCT) are the gold standard in causal inference. They provide us with a tool for a clear identification of causal parameters by randomly selecting the group of participants to the program and a group of non-participants.

The idea behind this is very simple: by randomising access to the program, there is no characteristic (observed or not) that makes the group that participates in the program significantly different from the group that does not participate. Therefore, comparing the group of individuals who participated in the program with the group that did not participate provides meaningful insights on the effect of the program.[4] This approach allows us to analyse effects by groups defined by observable characteristics. For example, it would be possible to identify the average causal effect of the program for girls and for boys.

An RCT is currently ongoing in the Fabschool project, covering around 1,000 students in six cities, who are following similar courses proposed by FabLabs during the academic year 2021-2022. The classes of students who can apply to the program are selected randomly and a survey is conducted before and after the courses by both the group of students who follow the digital fabrication courses (treated group) and the group of students who do not participate in the courses (control group). The objective of the analysis is to identify whether the course has an impact on a set of variables, namely the interest in STEM, the professional aspiration of the students, the university career choice, creativity, and grit.

The advantages of the RCTs come with some costs: they are generally expensive and require a large number of observations for inference. Moreover, they can present ethical problems. In the school context, for example, it is not always easy to justify why a group of students is excluded from the courses. In the following sections, we present examples of tools that can be used when conducting an RCT is not feasible.

2.2. Matched-comparison group design

When an RCT is not practical or possible, a matched-comparison group design can allow the evaluator to make causal claims about the impact of aspects of a treatment without having to randomly assign participants. The goal of matching techniques is to identify treatment effects by comparing individuals who are similar in terms of observable characteristics. One of the instruments to implement this method is the regression analysis.[5]

The regression analysis consists in estimating the statistical relationship between a variable (for example, the interest in STEM subjects), often defined as outcome, and a set of variables, called regressors (for example, the

[4] It is important to point out that, since it is virtually impossible to infer what the effect of the program is for single individuals (this would require the knowledge of counterfactual words in which the single individual did not enrol), RCTs allow us to identify average causal effects.

[5] We refer here to the regression analysis as a matching method in line with the interpretation in Angrist and Pischke (2015). This method has different applications as shown in Education Development Center (2017).

participation in a digital fabrication course, gender, age, etc.). Regression-based causal inference is predicated on the assumption that when key observable variables have been made equal across treatment and control groups, the section bias from unobservable factors is also mostly eliminated (see chapter 2 of Angrist and Pischke, 2015).

The regression analysis delivers the possibility to control for confounding factors that contaminate the relationship we are trying to capture. For example, conjecturing that girls are less likely to enrol in the digital fabrication program offered by FabLabs, we may control for gender (adding gender in the set of regressors) in our analysis to net out its impact on STEM interest. For this approach to provide a causal interpretation, we should control for every factor influencing individual decisions. However, there may be some unobservable characteristics driving the selection into the programs, which might be virtually impossible to control for (for example, in the school context, the information on parenting style might impact the interest of girls to join a program but would not be easily observable).

2.3. Regression-Discontinuity Design

Regression-discontinuity design is another quasi-experimental approach that can be used when RCT is not feasible. Its intuition is similar to an RCT, but the difference is that instead of selecting randomly the two groups (treated and control groups), the participants in the groups are selected by identifying a threshold in a certain variable that characterises the individuals (in the school context, this could be a test score or family income, for example). If the group that can participate in the treatment is based on that threshold, looking at differences between individuals just above and just below the threshold would intuitively deliver information on the extent of the treatment effect.

Bringing this example to the school context, the digital fabrication courses could be offered only to students with an average grade in maths above 8. After the courses, the analysis on the effect of the courses on the variable of interest (in our example, interest in STEM) could be done by comparing the variable between a group of students with an average grade in maths just above 8 who participated in the digital fabrication courses, and a group of students with an average grade in maths just below 8 who did not participate in the courses. Given that the two groups, treated and control, would be more similar the smaller is the distance from the threshold selected, it is important to choose a threshold that reasonably allows for a high number of students in the two groups. Also in this case, it is important to understand the assumptions behind the method which are needed to claim causality between the courses and the interest in STEM (more information can be found in Angrist and Pischke, 2015).

2.4. Instrumental Variables

The instrumental variables approach is another quasi-experimental method. It consists of identifying a third variable (instrumental variable) thought to influence only the selection into the treatment condition (for example, in the school context, an instrumental variable could be a random assignment of incentives to participate in the program, such as a presentation of the courses or the provision of credits).[6] Using this variable for the regression analysis, it would be possible to identify the average direct effect of the treatment (in our case, the digital fabrication courses) on the outcome variable (in our case, the interest in STEM subjects) independent of the unobserved sources of variability (Mehta, 2001). In this case, the interpretation of the results would change slightly, as pointed out in Angrist and Pischke (2015), but we would still identify causal parameters.

2.5. Difference-in-Differences

Having at our disposal information on individuals over time may help us overcome the selection effect through another quasi-experimental method, the difference-in-differences. This method captures the significant differences in outcomes across the treatment and control groups, which occur between pre-treatment and post-treatment periods. An outcome variable (which in the school context could be the interest in STEM subjects) is observed for one group before and after it is exposed to a treatment (in our example, the digital fabrication

[6] In other words, the effect of the instrumental variable on the dependent measure is entirely mediated via its effect on the treatment assignment. This condition is also known as exclusion restriction. The success of this strategy rests on the reasonableness of the assumption of exclusion restriction. See Mehta (2001) for a detailed explanation.

courses). The same outcome is observed for a second group (control group) that is not exposed to the treatment (that is, the students who do not follow the courses). The change in the outcome variable in the treatment group compared to the change in the outcome in the control group gives a measure for the treatment effect.

Using again the example concerning students and digital fabrication courses, we can imagine a situation in which teachers decide which classes would participate in the program (treated group). We can conjecture that teachers would select classes with higher needs for the course. We decide therefore to collect information on the outcome "Y" (for example, interest in STEM), before the program starts, for both the treated group and another group of students who do not join the courses (control group). At the end of the program, the value of "Y" over time could have changed for different reasons, such as, for example, stimulating the academic year's syllabus.[7] Under the assumption that the changes experimented with over time are the same for both groups, the difference of the differences of the outcome "Y" in the two moments of time between the two groups would deliver the average effect of the program.

2.6. How to interpret impact evaluation insights

Even though the evidence gathered through impact evaluation methods is strong and allows us to identify a cause-effect relation, the results still require interpretation and contextualization. The quasi-experimental methods can provide a valuable alternative when the RCT is not possible, but they come at a cost: assumptions. Their validity and implications vary by situation. It is crucial to justify them theoretically, and perhaps test them, if possible.

There are also some important aspects to consider. In particular, the treatment should be the same for the entire treated group (e.g. all students should follow the same course), or alternatively if there are more treatments offered, there should be a track on who has followed a specific treatment. Moreover, it is important that there is no transmission of information between the treated and the control group. In school, this would be the case if in a single class one group of students can follow the course and another cannot. Participants would likely share their experience with their classmates. To avoid this, there could be a selection at class level or even at school level. Also, it is important that all students in the treated group actually follow the activities, as otherwise the effect would likely be imprecise.

3. CONCLUSION

This short paper aimed at providing a general overview of the instruments that can be used in the context of a project evaluation. The selection of instruments should be based on the specifics of the programs and its purpose. Some of the instruments are relatively simple to implement and could be implemented in virtually all projects (for example, interviews and surveys). Others require more resources and capabilities, in particular when it comes to implementing an econometric design such as an RCT with the objective to measure the impact of the project. However, these designs do allow us to identify a causal relation and provide a sound analysis on the efficacy of the program design. Overall, collecting data and conducting an evaluation should be a standard practice in school projects, so that lessons can be learned, mistakes corrected over time and best practises replicated.

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[7] In this case, the assumption is that the outcome "Y" of the two groups of treated and non-treated evolves over time in the same way.

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Culturally responsive maker-space learning model towards meaningful education for marginalised communities

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ABSTRACT

The following paper discusses on various aspects of maker spaces in Ramdwari village bringing a meaning to traditional practices by establishing a link between local practices and conceptual knowledge and frameworks.

KEYWORDS

Contextual; Cultural; Maker-Spaces; Grass-root innovation

1. DESCRIPTION

The organisation started working towards co-creating every village as a centre of innovation and every child as an innovator facilitating social change since 2013. It is working in 5 public schools of Lucknow district and one after school learning program in village Ramdwari.

The organisation is a not-for-profit organisation working in the field of alternative education. Out of the various project locations, one of the maker-spaces resides in village Ramdwari of Sitapur district in Uttar Pradesh since 2013.

Lack of education amongst the population, poor infrastructure facilities, culturally rooted orthodoxies, social inequalities, recognition of local knowledge were some of the challenges to the development of the village Ramdwari people. With no other aid in sight, the founders themselves decided to step up and co-founded the organisation to bridge the gap in the education system of the village and work towards the goal of community development through education.

The maker space is based at Ramdwari village of Mahmudabad Tehsil, Sitapur district, Uttar Pradesh. The village has a population of 1,497 people based on 2011 Census. The total literacy rate is around 54% out of which male literacy rate is 59% and female is 48%. The literacy rates are far lower than the state average of 68% and national average of 74%. Families are engaged in agriculture and women are housebound, engaged in daily chores and looking after the children. Young boys and men migrate to west India in search of stitching and embroidery jobs for livelihood. Adult literacy is almost non-existent and even the children do not study beyond classes 4-5. The boys often start working before their teenage years and the girls are married off by the age of 13-14. The villages lack basic infrastructures such as roads, sewage, and toilets in homes and even medical facilities. The learning community is engaged in various local practices, art and culture like chikan-kaarigiri, bamboo weaving, zardosi and many more.

1.1. Description of the educational experience

Coming from the backdrop of Krishnamurthi school of thought and democratic schooling, our values evolved around freedom of choice and expression, learning by doing and making learners active and informed members of the civic society. We thought of integrating it in the student's thinking and mindset but the road wasn't smooth. In our first project with children we failed miserably. The children were asked to make something innovative in an 'innovation lab' from the decontextualised material given to them. They only made things that were familiar to them and could not make anything new or innovative. Now when we reflect back it was a useful lesson which taught us that it is imperative to build community context and children-lived experiences together in the teaching-learning process. As we went deeper, some local issues and problems erupted. For instance, villagers had to walk 5 kilometres to charge their cell-phones as the village did not have electricity supply. After some sessions around alternative sources of energy and some exposure through books and videos, children at the centre assembled the related material and made a solar mobile charger that helped the community to charge the cell-phones in the village itself. This form of education attracted the community's attention which led to boys joining the after school learning program along with the girls.

There were lots of interesting projects that started taking place but certain deep-rooted problems also erupted. Issues around gender became apparent when objections were raised by the community against boys and girls sitting together in our classes. Girls' mobility outside the village was frowned upon. We adopted the storytelling pedagogy and looked closely at its impact on shifting the mindset of the community and children towards each other. When the boys of Ramdwari village centre listened to the story "Cycle par sawaar auratein (female on bicycles)" in which a young brother helped his sister to ride a bicycle so that she could go and study in a school, they were inspired to attach an umbrella on the top of a bicycle and a plastic sheet at the back so that the girls of Ramdwari could attend school during rainy days. The umbrella covered their body and the plastic sheet covered their bags. It showed us some snippets of children starting to think and question the gender issues and also working on the same.

As children started to engage in the education process with us, enrolments in formal schools started to increase with both boys and girls joining mainstream schools. When children were exposed to mainstream schools they felt completely disconnected with the school curriculum as it lacked connections with their local language, culture and art and also dominant ideologies were being continuously reinforced. The interest that had been generated was soon beginning to die as the school education lacked connections with their local knowledge. Therefore we felt the need to explore ways of integrating local and community knowledge into the curriculum so that children continue to ask questions, challenge the status quo and move towards social justice. We had a dialogue with the community members in which we found numerous examples in which connection of local knowledge with mainstream education is there. One of these being extraction of peppermint oil from the crop which involves a process of evaporation and condensation. We applied the local knowledge of peppermint oil extraction which was known to all the villagers to help the children understand the concept of water cycle. This made them realise that the local knowledge can be extremely scientific and logical.

Learning from the above example, the children collaborated with the potter of the village to devise a matka-cooler (earthen pot cooler) which kept the water cool during summer and when attached with a fan and a battery, provided cool breeze to all of us. The children started applying local knowledge to solve local problems, but still the questions of freedom of choice and social justice wasn't being addressed very centrally. In all these projects, the children used a variety of tools and equipment. Some of the tools like axe, screw drivers, glue gun, soldering iron, knife cutters, wire cutters, utility scissors, saws, hand drill, cutting blades, measuring tape and many more. Some tools are available in the village, while some were procured from the market.

One important point that came during the projects was the support provided by the facilitator. The facilitator acted as a trigger which put forward some challenges in the environment. The mind-mapping, design thinking was done by the children and thereafter it got discussed with the facilitator. The facilitator guided student's thinking towards making something which is resilient, cost-effective, contextual and will be used by the community people. It was decided in the maker-space design that children would discuss their reflections, concerns during the question hour organised everyday by the facilitator and thereafter the children work in teams to make new things. The facilitator supported student's thinking by not providing direct answers but guided their thinking.

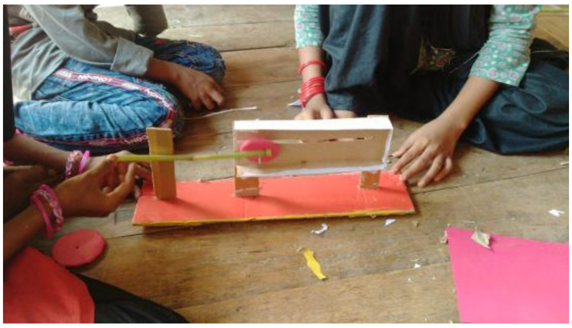
Then came the turning point when discussions around Citizen Amendment Act (CAA) and National Register of Citizens (NRC) started and children began to raise questions about their freedom to live and move in their own country.

In one of the sessions, we tried to give the children exposure to different revolutions that had happened across the world whether it was a movement against slavery in North America or Narmada Bachao (Save Narmada River) movement in Madhya Pradesh. To prepare for such a session, the facilitator researched on various stories, artefacts, videos to develop an enhanced understanding about the issues. Thereafter, children were exposed to stories, videos and art forms which seemed to transform their thinking. In the movement against slavery, the activists in the book made a quilt to make a route to escape. Also the documentary 'Stitches Speaks' which celebrates the art and passion of the Kutch artisans and traces the multiple journeys made by the participants towards defining their identities in forming Kala Raksha Trust and School for Design influenced the young minds of Ramdwari village.

Apart from the above, children were given exposure by the facilitator to stories, poems and songs along with their historical context of various activist writers like Ismat Chughtai, Faiz Ahmad Faiz, Safdar Hashmi. With such a background of positive activist movements that happened across the world, the children of Ramdwari also started to raise their voice for their own rights. Among other things, they made slogans, depicted stories through their local Chikan-kaarigiri art and held silent demonstrations. It was the beginning of a big change towards innovation. The students researched on local practices and objects (like umbrella, bicycle, hand-pump, bamboo basket), studied various concepts associated with them, made prototypes of grass-root solutions to solve local problems which can be implemented in the community.

Some of the examples of educational experience are as follows in which the intent is to nurture socio-scientific temper through contextual and cultural maker spaces.

1. Learning about constellations through Umbrella : It is a local object which children in the community explored to understand the mechanism of the same. They explored the principles of hydraulic pressure in operating an umbrella. While observing the clear night sky in the village and looking at stars and the moon, the children thought that can they depict the constellations on the umbrella. Stars and moon are quite important in the community practices as many of the festivals or traditions are dependent on their movement. The children tried, sewn the thread inside the umbrella and when they opened the same, constellations were quite visible. It made connections for a child building from their local practices and linking to a more scientific knowledge giving importance to contextual and cultural making.



2. Understanding Intricacies of air pressure Hand-pump : It is also a local object in which intricacies of hand-pump were explored by children engaging with making a prototype of a hand-pump after observing it in detail. The children studied about the concepts related to crank, valve and washer by making the functioning of the same through contextual and cultural maker spaces. At the end the children applied the concepts in depicting a fictional story. By making the prototypes of mechanisms which were used in the working of hand-pump, the children could understand how so much water could come outside from the bottom of the earth.

3. Applying the principles of bicycle to solve grass-root problems : The children took apart the various parts of the bicycle and understood the mechanisms of the same. The children then researched various applications of bicycle which was in use in day-to-day life of the community and how it can be applied to solve the problems in the community. It led to children making a bicycle-enabled fodder cutting machine, cleaning garbage from the drains in the village to avoid flooding of roads during rains and umbrella on the top of the bicycle so that children could attend school during rains.

(Refer to the link : https://bit.ly/2ZS3pd7)

2. CONCLUSION

2.1. Results

In summary, the contextual and cultural maker spaces in village Ramdwari has been able to provide the right stimulus to children and to the community for continuing with education and understanding the merits and relevance of the same. The girls are able to break the stereotypes by challenging the status quo by working in maker-spaces and pursuing higher education. It has been an important element that a village in which children used to hardly study beyond grade 5 are completing a minimum of grade 12 while inter-mixing the conceptual as well as hands-on knowledge and skills. The children started to value the knowledge in their local traditional art, craft, practices and objects and linking the same to build a far greater and deeper understanding of the concepts.

The experience of working with children was full of learning as lot of places as an educator one finds to be without answers and it is through continuous exploration, trying out newer solutions that one gets to understand the things more deeply. The most fascinating part is that the path is not frozen but one has to carve out its own looking at different perspectives. As a facilitator, the culturally responsive maker-space evolved in a phased manner and reflecting on the same it came about in three phases — the first one being 'the maker transforms the material' the second being 'the making transforms the maker' and the third one is 'active engagement beyond making'. The same is evolved over the years and it is a cyclical process which will transform the learner and community in the years to come.

We would like to involve more of adult community members in the contextual and cultural maker spaces so that there is deeper amalgamation of traditional knowledge with the newer generation. The community members have been able to understand the merits of education which led to girls not getting married at the age of 12-13 years while were allowed to pursue higher education. The boys who were asked to migrate to bigger cities now are completing their education.

2.2. Broader Value

Now, over the years, what we have seen is evolution of new learning models nurturing socio-scientific temper in the community emanating from local practices and traditions, local research, building up of conceptual understanding through contextual and cultural maker spaces and applying the knowledge and skills to further delve on the same as well as solve some of the grass-root challenges moving towards social justice and equity.

The knowledge of marginalised communities were not given due preference and recognition and due to this they themselves do not understand the worth of it. This new learning model helped children and community in understanding the worth of their own traditional knowledge. It helped to understand various concepts and principles through their community knowledge and expand it further in creating new knowledge.

Additionally, I would like to share that resources are never a constraint in the rural learning community, in-fact they have the maximum in terms of contextual material and cultural know-how. We tried to build from the local practices, objects and environment through a contextual and cultural maker spaces in which the solutions are co-created which led to greater acceptability and its implementation. One of the key learnings of contextual and cultural maker spaces is children co-owning the space and driving lot of innovation projects in which we acted as facilitator in the learning process.

2.3. Relevance to Theme

Our work revolves around contextual and cultural maker space which lies in the theme of ‘Maker Pedagogy’ and the relevant topic is ‘New learning model’.

Tinkering with Biological Materials

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ABSTRACT

In this paper I describe a series of biotinkering activities in a public elementary school on the edge of Rome. The experimentation started last year and is still in progress. It involves three classes of nine-year-old girls and boys.

KEYWORDS

Biotinkering; Primary school; Cultural Making; Sustainability.

1. INTRODUCTION

Over the years I have often searched for how I could work in a school fablab or a makerspace in a sustainable way. The answer came two years ago when I discovered the DIY Bio movement. What is DIY Bio? "Is a growing biotechnological social movement in which individuals, communities, and small organizations study biology and life science using the same methods as traditional research institutions"8. After that discovery, I searched online for some time, but hesitated in proposing this kind of activity because the examples that I found often used special tools and required specific knowledge, for example equipment for electrophoresis or DNA sequencers.

I found courage after discovering Corinne Takara's activities and her Nest Makerspace (Takara, 2021). Following her work, I discovered that in addition to biohacking: "scientific experiments with biological material, done by people who are not official experts or scientists"9, there are also biomaking and biotinkering that is, building or tinkering with materials having biological origins. Biotinkering was just what I was looking for to be able to learn with my primary school students.

The modern world distances people from the world around them. It becomes more difficult to see the connection between our identities, culture, and the materials we live with. We do not see that materials are important and that waste causes harm not just to the environment, but to our sense of self. When we use materials that are part of our places and culture, we can trigger stories that can bring us closer and emancipate us towards greater knowledge and awareness of who we are.

Paulo Freire criticized school because it decontextualized the curriculum and the students lost touch with their own cultural reality while it was necessary to dedicate themselves to significant problems for the community and with the community (Freire, 1974). Seymour Papert shared Freire's enthusiasm for the liberation of the learning potential present in every student and starting from Piaget's constructivism he stated that the construction of knowledge occurs when children design, build and publicly share their work, in fact when the product is shown, discussed, examined and admired, a reflection phase is activated and leads to rethinking and improving the project, expanding the design and creation process, creating a deeper understanding of the subject and a meaningful learning (Papert, 1980).

Based on these assumptions I tried to connect context, community roots, and sustainability to make meaningful learning happen.

2. DESCRIPTION

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[8] Wikipedia, https://en.wikipedia.org/wiki/Do-it-yourself_biology (ver. 02.11.2021)

[9] Cambridge Dictionary, https://dictionary.cambridge.org/it/dizionario/inglese/biohacking (ver. 02.11.2021)

2.1. Background

This paper aims to report biotinkering experiences carried out during school year 2020-2021 and still in progress, in a primary school near Rome. This text is not intended to explain exhaustively the tools of biotinkering or the methodologies used but to report a meaningful experience for many boys and girls. The school is located in a peripheral neighborhood where there is a lack of structured opportunities or places to socialize. The origin of the inhabitants is heterogeneous and often there is no family support network.

The area is characterized by a constantly increasing population, both from non-EU immigration and from internal immigration of families who move to this area for work. As a periphery of the metropolis of Rome, it attracts families, even multi-problematic ones, and commuters who move in and out during the day for work or study.

High immigration rates exacerbate housing problems and socio-economic emergencies. Immigrant citizens find employment mainly in the agricultural and construction sectors, sectors that are insufficient to meet the growing demand for work. The absence of a residence permit means that many families cannot turn to institutional services. The condition of minors is only one of the emergencies occurring in the community.

The children, living in a very difficult social context as described above, were also coming from a lockdown school year due to the COVID-19 pandemic and anticipating a new one full of difficulties, social distancing, and possible quarantines ahead of them.

2.2. Educational Experience

In this context, I decided to experiment with a path of self-production and biotinkering with the girls and boys of the fourth grade, one hour a week for 20 weeks. Kids involved in the learning activity didn't have previous experience and one of the first challenges was to find good materials to use. They need to be low cost, easy to grow, should not be frightening, and should stimulate creativity and curiosity. The first experiment I started was bioplastic production with sodium alginate, a material extracted from the cells of brown algae and used in the kitchen as a gelling agent, and calcium lactate used as a leavening and acidity regulator in pastry.

Image 1. Tinkering with Bioplastics examples

The results were fascinating! Children started trying to make shapes that were not well defined until one of them thought of trying to spread the alginate gel in a mold. It was wonderful to see that without any explanation and guided only by collaboration, curiosity, and creativity kids created wonderful work. We discovered later that this technique is used in molecular cooking for spherification, for example, bubble tea! The main difficulty was to keep the shape once the compound was immersed in the calcium solution. They invented collaborative problem-solving processes in the face of a concrete problem.

Many of the biotinkering project ideas on the web used raw materials very distant from our local culture. I wanted to use materials closer to the experience of children. Starting from their own culture, they can rediscover their origins and create a connection, even an emotional one, with the places they live in and which they often do not know. Taking care of the community also through the recycling of waste elements such as coffee grounds or eggshells. Starting with these products I proposed to make materials taking inspiration from materiom.org. This website collects many recipes based on the use of natural ingredients.

Image 2. On the left a coffee ground bioplastic and on the right a lamp created with it

Once the starting material was produced, everyone could express their creativity and use it within a larger project, creating tangible products. It is a strong emotion to see the joy in the faces of students when they hold their creations in their hands and show their works. Usually, the first thing they ask me after the project is done is: "Can I take it home?". It is a real thing that they can proudly show to the family and say, "I did it!" Making can help children of all social and economic backgrounds construct their learning because "there is hope for every child" (Harel, 2016). Producing objects is essential to who we are as human beings and makes our ideas understandable to us and even to other people.

The latest material we have explored is kombucha leather. Kombucha is a fermented beverage enjoyed for its unique flavor and powerful health benefits. The fermentation process creates a scoby–a thick, rubbery, cloudy mass. Drying the scoby creates the kombucha leather, a flexible material that kids used as a fabric and they embroidered the leather with designs created in Turtlestitch.

Image 3. Embroidered kombucha leather

The production of kombucha, like other materials, requires patience and care. Before using the material, children need to wait, observe, and understand whether the conditions are right to form the material. This leads to a twofold action: caring for something so that it can develop, and scientific observation of variables to assess the best conditions for growth and/or production of the material.

At the end of each lesson, students share what they did in a group or working alone and describe functionalities and relevant aspects of the project, after that, they use their logbook and note down the work they have done, explaining what activities they plan to do in the next lesson and analyze what they feel satisfied with. It could be a decoration, a working circuit, or a collaboration with a partner. It could be what disappointed or irritated them and they think they could have done differently, maybe a part they failed in, like a bug in the code. This aspect of self-assessment helps the students a lot because it works as a reminder to understand in the next lesson the point at which they had arrived with their work and then they can analyze their strengths and weaknesses coming to a more or less in-depth self-analysis.

3. CONCLUSION

3.1. Results

The first observation I can make about the experience is an increased awareness by students. Awareness of the material origin—now they know what raw materials the product comes from and what elements to choose to generate a material that is more rubbery or more rigid than another. They have also become aware of the sustainability of a biodegradable product rather than one with a negative environmental impact, and last but not least, they are aware of the time and effort needed to produce it, with a consequent attention to its consumption. For products like kombucha leather, in fact, I noticed a great deal of attention to minimizing waste because the children knew very well the time they took to produce it. As a teacher, I can say that it is an enriching experience. It is not easy to manage biotinkering activities at the organizational level because, you often need heat sources for the production of bioplastics, with consequent challenges related to the safety of students or you need to set up special spaces for the culture of materials such as kombucha. On the other hand, it's great to experiment and learn with my students. As is the case every time I offer tinkering activities, I also challenged myself on my ability to facilitate group work and to handle frustration with an activity that did not turn out as well as the students expected. The limitations I have found are primarily due to time. A single hour a week is not enough to work on the project because between the arrangement of the materials and the resumption of the work, most of the time was used up. Time was even more limited in the culture production phase. Here we had moments of observation and recording of the state of the product in the first part of the lesson, while in the second part of the lesson we worked on previous projects with other materials. I hope that the work started at school will be a starting point for conversations at home and with classmates. For the children, bringing home a product made entirely by them is the best way to get them involved and give them ideas to perhaps reproduce the activity with their families and raise awareness in the community about using sustainable products that are linked to their own culture and to reducing waste and scraps.

3.2. Broader Value

Biotinkering is still a very new activity in schools and for this reason still not well known. Thanks to the community of educators on social networks, I came into contact with pioneers in this field who gave me many ideas and support. I was able to ask for information, suggestions, and clarifications from people from all over the world and I am sure that without a group of teachers with the same goals and interests I would not have been able to find the keys to make this experiment so successful. I hope that this witness can be a starting point for other teachers who are looking for a more sustainable experimentation linked to the culture and the territory in which they live. In the future I hope to expand the trial to more girls and boys. Tinkering and making have taken off in Italy in recent years and many educators have appreciated its potential. The commitment is to be able to see the emergence and contribute to the construction of a local community around the themes of constructionism and pedagogy as a practice of freedom.

3.3. Relevance to Theme

I believe this paper has strong connections with the maker pedagogy theme for this year's conference. In particular it can be related to the experimentation of fablabs and makerspaces in primary school.

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TikTok as a learning environment in primary school

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ABSTRACT

The paper describes a didactic project on using TikTok as an authentic learning environment for the development of literacy skills, with high cross-disciplinary level, in a fourth grade of primary school of an institute close to Turin, lasting fifty hours. The class consists of 22 pupils, one of whom is second-generation foreigner. The focus will be on the production of digital storytelling by students and teacher, identifying this experience as a good practice of renewal in primary school.

KEYWORDS

TikTok; digital storytelling; performance; media education; primary school.

1. DESCRIPTION

1.1. Description of setting

The didactic design has been put in place in a school that is part of an institute of the province of Turin. It is therefore considered useful to describe the socio-cultural background to this project. The user is heterogeneous, there are several foreign pupils. There are also significant socio-economic differences in that the school is in a newly renovated area and therefore revalued where, as a result, new users of higher economic groups have arrived. Therefore, the structure is faced with a multiplicity of needs, this is the response to the many different projects to which it adheres.

The 4B class consists of 22 children. There are two pupils with special educational needs in the certification phase related to Specific Learning Disabilities and a child with BES of third class as a second-generation foreigner with the need to strengthen Italian as L2.

The peer group is united. There is a dynamic of healthy competition fueled by teachers. Pupils are accustomed to the authoritativeness of the teacher, the way of management privileged by the teacher is therefore not directive. The teacher places the pupils at the center of his educational interest and therefore at the center of his educational activity. Children are central to building their learning, as social co-construction. The preferred teaching methodology is cooperative learning and flipped classroom. Spaces of dialogue are valued. Students are used to putting themselves in the game. They feel free to try, think and express themselves. There's a strong climate of mutual respect in the classroom.

1.2. Description of the educational experience

We live in a society in which social media are so pervasive in everyday life that with the physical environment we form a single system-world in which the subject experiences his own life, co-builds his own identity and learns with the world.

In the institutional field these considerations are very relevant as the medial transformations have led to the birth of a new man to be formed, the *mediantropo* (Denicolai, 2018), with peculiar communicative skills, cognitive and social, which mobilizes and at the same time requires the acquisition of new skills in its process of knowledge and experience in the world.

Adhering to the theories of Neil Postman (1968), who considers the media as environments in which human experience takes place, it is possible to infer that social media are an authentic living environment like physical environments as they guarantee similar cognitive, social, emotional experiences. Therefore, if the cognitive, affective, social reconfiguration of man is placed within the relationship with the media, then the educational context, for the purposes of educational success, need to reconfigure itself.

The design, however, is based on a survey of training needs derived from an observation in the field. So, this project was born to respond to a concrete need of today's children. During my daily work in the classroom, I found myself observing a very responsive response from the students to any stimulus related to the media environment of TikTok, I witnessed the identification of a communicative code shared among pupils, born from the context of TikTok. Of course, I had the opportunity to observe functional and dysfunctional behaviors deriving from the use of this social media, so I asked myself: can prohibiting the use of TikTok be a real solution? Why, instead, not exploit the potential of this informal learning environment in the educational field and at the same time provide students with a healthy and constructive operating model?

The class group undertook an educational path aimed at the study of the *Odissea*, inserted in the context of a sense of intercultural issues such as travel and immigration. The didactic project is inserted within this frame of meaning as a continuum of this didactic design. It was planned to use TikTok as a learning environment in which experiences of digital storytelling production and fruition took place, in relation to the story of the author Fabio Geda (2010) *Nel mare ci sono i coccodrilli,* in interdisciplinarity with historical and geographical themes, art and citizenship education, with particular focus on production and narrative reworking. The educational intervention aims to promote the skills of new media literacies, involved in the process of digital storytelling, emerged in the post-media era, in close connection with the European skills, focus on prose and document literacy. The transversal skills promoted are social and civic skills, digital skills, learning to learn and spirit of initiative and entrepreneurship, consistent with what is specified in the *Indicazioni Nazionali* 2012.

The purpose of the didactic intervention is, therefore, to educate the pupils, and the teacher, to write with the media.

The activities were carried out in mixed mode, in presence and some at a distance, in synchronous and asynchronous mode, the school setting was sometimes organized in stations, sometimes in islands and the teaching methods involved were different, analyzed later in the individual activities.

As for the activation of the didactic intervention, it is necessary to point out that in agreement with the DPO it was decided to create an account exclusively of the teacher, protected by privacy, and an account of the class group, private and with limited content, whose username and password management was exclusively of the undersigned and the direct use of social media by the pupil took place exclusively in school hours with the close supervision of the teacher in relationship 1:1 or 1:2 and a document of consent for parents on the use of the platform for educational purposes has been prepared, the faces of the pupils have never been reproduced or sensitive data published.

The main phases of the proposed training model will be analyzed below.

1.1.1 TikTok creative process

The first phase of the project consists in the administration of a questionnaire through the Google application modules, aimed at understanding the access by all pupils to digital resources, if in the family had devices and an Internet connection, and aims to analyze how the media environments of social media are a pervasive presence in the everyday life of students and beliefs about the use of these platforms in everyday life and in the school context through brainstorming and playful activities.

With the second activity we entered the merits of experimentation. The first phase was carried out in synchronous mode, the classroom setting was prepared for islands, having for each island a tablet, supplied by the school, implementing the small group learning methodology alternated with moments of debate with the entire class group. I launched a first short video lasting 15 seconds and each group participated in the use of the multimedia product, whose adjective is significantly connoted by the meaning expressed by Drusian (2018). Through the audiovisual artifact, the first inputs were provided to introduce the new themes, in continuity with those dealt with in the previous didactic design. Three inputs were provided: Odissea, sea and cultures.

At the end of the video, it is proposed to children to individually process media products, in response to the content proposed by the teacher, in which they develop the input given by the teacher. The objective, therefore, is to trigger a process like the brainstorming process, that is to trigger a creative playful process in the association of ideas, in this case with material for dramatization, and other material produced by the students themselves, in support of digital storytelling. Pupils produced and shared videos on the platform (Figure 1), with the possibility to comment the other videos. At this stage of the activity, I worked with the pupils in 1:2 ratio, to monitor responsible use of the platform.

Figure 1: some short videos produced by the students, common characteristic feature: creative reworking of the Odissea.

With the same mode used in the first phase of the activity I published a second short video in which the transition from the era of Ulisse to that of Enaiatollah Akbari was outlined. The class, in small group learning, actively used the artifact produced by the teacher, this was followed by a moment of collective debate in which the social significance of everyday heroes was reflected. In this case the short video produced by the teacher, was an input to activate a process of problematization of issues, implicitly this activity provides an operational model of the problematization of online content, induces pupils to reflect critically on what they have seen and heard, without merely benefiting from it. Subsequently, the pupils received a final video in which the title of the book, the author, the name of the protagonist and the geographical context were briefly presented. This is another input for students who have been asked to produce an asynchronous research, one group has been involved in research on the author, another group has developed the research on Afghanistan, home of the protagonist. The synthesis of this research took place through the production of two short video (Figure 2), in which one exponent synthesized the essential contents of his work. All the participants of the group contributed to the filming, the organization of the exhibition and the assembly.

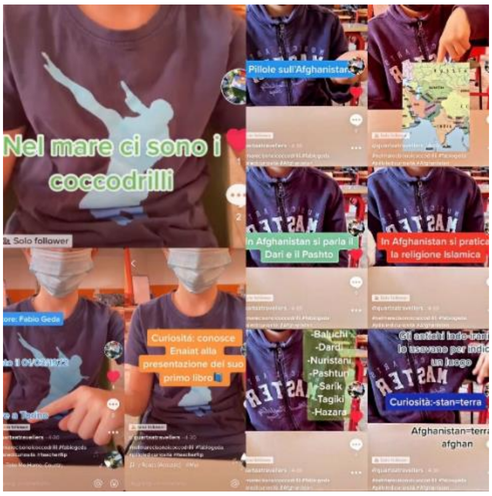

Figure 2: short video on the research carried out.

1.1.2 Digital storytelling

The third phase focuses on the construction of digital storytelling of the story. I published two videos of fifty-nine seconds each, in which the story is narrated. Only the first chapter is reproduced by the teacher, the others will be narrated by the students divided into pairs that in 1:2 relationship with the teacher will deal with the narrative production. There are two reasons why I decide to entrust the teacher with the task of the beginning of the narrative: to provide an operational model to the pupils and to allow the teacher himself to be aware of all the procedural phases and cognitive processes put in place during the activity. The narration takes place in the following way: through the time-laps technique the hand of the narrator is taken during the drawing of the main scenes. The narration therefore follows the flow of images drawn by the narrator, the drawings or better the gestures made during the act of drawing, accompany the narration. Images are drawn and often accompanied by evocative gestures, by functional shooting techniques and the design itself is integrated, as well as with gestures, with elements of the real world. Emoticons, slow-motion effects, short written texts, and background audio tracks are added to add meaning to the narrative. Once all these elements are assembled, the narrator's voice of the story is recorded. The students in pairs continued the storytelling undertaken by the teacher, task of each couple was to produce a digital storytelling in which they told a chapter of the book to the others pupils through the approach of peer education (mix digital storytelling). Every week we worked with a different couple. Each couple, weekly, was given a job to be carried out in asynchronous distance, the reading of the chapter of the book. Later in synchrony with the supervision of the teacher the couple conceived the concept together, choosing the main events and topics to be included in the storytelling. The couples therefore summarized the chapter and created a draft storyboard useful to produce storytelling. Only once through these stages the couple proceeded with recovering during the act of drawing, then assembling the content with text images, effects and transition and then writing a script to follow to record the vocal narration, For the script it was very useful the summary work done at the beginning. The teacher explained the early stages and left the pupils free in filming and editing to observe their creative process. The moment of sharing the experience with the companions is important, carried out at the end of each week at the end of each chapter, in which the same pupils had the opportunity to receive feedback from the peers on the effectiveness of communication, useful element for self-evaluation. In addition, these moments were always accompanied by debates on social issues emerged from the story, often influenced by historical issues such as the phenomenon of immigration and reference to issues of citizenship education with reference to the rights of children with inference to the *Agenda 2030*, and by in-depth activities, such as the compilation of a map of the stages of the protagonist, to keep track of the activity.

1.1.3 Challenge

The storytelling activities were interspersed with challenges related to the central themes of the chapter. At the end of the vision of the first chapter I launched a challenge #nascondersi (Figure 3) that resumed the central theme of the chapter. *The protagonist at only ten years is forced to hide in a hole not to be found by a rich gentleman. The question that has been asked to the students is: have you ever wanted to hide from something or someone?*[10]

A challenge has been proposed in which, by transition, snapping fingers, making a jump, the subject of the framed disappears and only his answer remains, symbolizing the need to want to disappear from something or someone. Intentionally it is not summery explicit the expected product, to understand the effectiveness and immediacy of communication of the video and observe their mode of spontaneous communication.

2. CONCLUSION

2.1. Results

As a methodological choice, it was decided not to use an evaluation section to analyze the case study, but to use an observational grid throughout all activities to reflect qualitatively on the whole learning process, therefore, the main conclusions reached will be given in descriptive form below.

[10] https://drive.google.com/file/d/1YqcmIT2UL8diP-ukdeassnq4OMF8pdYr/view?usp=sharing (Ver. 14/04/2023)

Data obtained from the preliminary analysis through the questionnaires confirmed the starting hypothesis highlighting the intense pervasiveness of social media even in the everyday lives of people under 13.

The second phase of the design allows to reflect on the potential of the *performance*; the students, in fact, according to a teaching methodology of learning by doing have lived a learning experience situated and deep activating processes co-narrative construction. In the progression of artifacts, it is important to note how they have influenced each other often triggering a real simulation process in which the structure of the artifact was congruent with that of the companions and to vary was the form. It is possible to note that in all artifacts the technique of dramatization has been used that, in addition to being an aid technique in the narrative construction of the story, has motivated them as actors, as writers and as creative producers. Thus, the functionality of this activity emerges in the training phase (Castoldi, 2020), through the mobilization of knowledge and skills, for the development of literacy skills of understanding a message. *The drama allows the writing to be visible, understandable, emotionally engaged and "spoken aloud" in an imaginary but living context* (Olivieri, 2020). Students thus make explicit, through narrative thinking, the processualism of the narrative, that Bruner himself (1986) considers fundamental to organize his own experience of knowledge of the world. The realization of the video-pills related to the research carried out triggers the activation of the problem-solving process, aimed at seeking the communicative strategy functional to the activation of mnemonic strategies useful to the user, the companions of the other group, both to the producer who mastered the content. Encourage pupils to seek the most effective strategies for transmitting content on which they themselves have carried out research, involves the activation of a process of metacognition which in turn enhances the competence to learn to learn and allows teachers to monitor the entire learning process.

The third phase is focused on the digital storytelling process through a peer production methodology. The choice of colors, images, tone of voice to use, communication strategies more effective to facilitate and at the same time give meaning to a cultural content, promoted the mobilization of knowledge and skills necessary for the development of functional and receiving alphabetical competence, relating to the comprehension of written text to produce videos and the fruition of the artifact for the audience, is of production in the creative act of digital storytelling As the expert Robin argues (2008) students participating in the digital storytelling experience benefit in terms of metacognition, as they learn to analyze their own work and that of others, involving processes of social learning and emotional intelligence.

As for the challenge it is possible to notice the ironic and sarcastic tone of some responses enhanced by the short form used for communication. The irony sarcasm, as explained above, are typical of these media environments, moreover, taking an ironic and sarcastic attitude is also a mirror of the activation of the creative process and critical thinking. The challenge has led to the introduction of deeper themes, such as bullying, which refers to the more traditional form of media education or awareness for the prevention of dysfunctional behavior (Revolver, 2020). In conclusion, the effectiveness of the didactic intervention does not lie in the mere transformation of paper content in digital format, but in proposing a training path that allows students to enter the process of media writing, therefore, not to be mere users, giving them the opportunity to deconstruct the social content they enjoy daily, often uncritically.

Use TikTok as social media has also made it possible to understand the potential of this platform in the socialization of experience because the class group were able to contact the protagonist of the story, who made himself available for an interview. The students prepared an interview for the protagonist and created a podcast of this interview through the *Anchor* application.

2.2. Broader Value

It is considered relevant to think that even the teacher uses this type of medial writing because this is the preferred language of the *mediantropo* in the postmedial era. The goal is that the teacher also learns and interiorizes these short forms of medial writing because of a primarily cognitive issue related to the activation of *mirror neuron* (Welsh, 2004), the pupil in a media environment, at the moment in which they participate as an audience in a performance, *learns by modeling* (Bandura, 1964) so the teacher must perform a performance that triggers creative processes of re-production of content, acting as a model in the syncretic language production. This teaching experience has allowed students to develop a new experience of social media, acquiring skills and operating models in support of a conscious use, but above all functional to the construction of significant experiences, annihilating the ignorance that media environments are only useful for entertainment. The hands-on mode of conducting the experiment has allowed students to implement informed choices in the communicative field and to develop metacognitive strategies through social learning, reflecting on intentionality and directionality communicative, through conscious stylistic choices. Finally, it is considered useful to highlight the degree of inclusivity of these forms of media writings arising in the world of social, in this regard the non-Italian student has shown a considerable active and constructive participation. Using these forms of syncretic writing allows, in fact, to respond to different styles of learning offering everyone equal opportunities of access to experience according to the epistemological framework of *Universal design for learning*.

2.3. Relevance to Theme

The effectiveness of design is given by the mixture of formal and informal learning environments. All the activities focus on the expertise of the students' producer. The hands-on mode promotes activation of authentic learning process in the media environment of social media.

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BIOS

The design was conceived and activated by the undersigned, Fabiana Barone. I am a primary school teacher, graduated in primary education sciences. During my university career I studied and conducted media education experiments in primary school, to date I am an independent researcher with particular interest in e-learning environments and the use of new media in different information contexts.

On my site http://www.fabianabarone.com/ it is possible to view the projects and products made with different primary school classes.

LEGO and Media Education during Technology school hours supporting inductive and deductive thinking

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ABSTRACT

The presented educational path is part of a three-year action-research project. The research is carried out at Comprehensive Institute A. Pacinotti in Turin, thanks to the collaboration with Cinedumedia Research Centre, which provided the LEGO kits for all the 3 courses, the necessary tablets and the participant observer. The presented course regard Construction science and it is proposed during Technology ordinary school hours involving 12-13 years old students. The courses prepared for the research project has been included in the PTOF (Piano Triennale di Offerta Formativa - Three Year Syllabus of Education) as part of the answer to the requirements of the National Plan for a Digital School (PNSD). During the first year of research (a.y. 2019/20) the Construction science course involved 2 classes, last year, as this year, we proposed the same pathway in 3 classes. The aim of the courses is to transmit highly complex topic in the form of a game.

KEYWORDS

Construction science; Media education; Think-Make-Improve; Cooperative Learning; Discovery Learning; Metacognitive and metareflexive capacity; inductive and deductive thinking.

1. INTRODUCTION

The course presented is part of a three-year research project, carried out thanks to the collaboration between Cinedumedia Research Centre and Comprehensive Institute A. Pacinotti, a public secondary school in Turin [1]. The research project began with the awareness that every educational action involves the *unexpected* and the *unknown* [2]: educators and teachers cannot follow strict schedule but must encourage everyday a particular range of educational actions [3]. To respect the singularity of every educational process, the group decided to propose an action-research project, that is based on observation and systematic collection of data, not just to know and understand the research context, but to support a real change, combining action and reflection, theory and practice [4]. This type of research allows us to model the design in the context, following the nuances and ripples, to make choices based on the response of subjects.

The hosting Comprehensive Institute is a public school which welcomes many students with specific learning problems (physical and cognitive disabilities, socio-economic and cultural discomfort). For this reason, the research group tried to design a lesson structure to involve actively every kid, no matter what disadvantage he or she has, providing a stimulating and formative environment able to support an early development of the skills necessary to grow as aware and responsible citizens. Considering the achievement of knowledge, abilities and skills required by the National Norm for the secondary school [5] as primary purpose, the research group decided to design an inclusive educational methodology combining the principles of Cooperative Learning, Media Education, Think Make Improve and Discovery learning, in order to reduce early school leaving and encourage a collective construction of scientific knowledge [6].

The research group of Cincedumedia centre decided to design different search tools, to collect at the same time qualitative and quantitative data. During every lesson we used two observation tables: the first one has been designed to observe the interaction teacher-students, student-student and student-teacher and it is used just during the first part of the lessons, which is dedicated to the theory; the second one is a simplification of Bales'

IPA [7]and it is used all along the meetings to monitor the social behaviour of the kids. The researchers prepared also five tests: we proposed an entrance and an exit tests designed to monitor metacognitive and metareflexive capacity, and three curricular tests to verify disciplinary knowledge, abilities and competences levels. Moreover, we daily produced video and audio registration of lessons, camp notes and proposed writing activity to monitor continuously students' level.

2. THEORETICAL FRAMEWOK

The purpose of the school has never been the simple transmission of knowledge, there has always been a specific educational aim. Nevertheless, if in the past the results of education could be measured through the evaluation of a performance, in XXI century high-quality teaching must be focused on a broad and critical cognitive training that allows to possess the knowledge both as skills and as metacognition and reflexivity, in order to promote full citizenship in the *knowledge society* [8]. However, the school environment cannot be conceived as a social context separated from life, conceived as a place where you learn lessons. It must be a miniature social group in which study and development are part of a shared current experience [9]. School education is not mere preparation for adult life: it should introduce everyone into new and never imagined fields of experience and reflections [10]. It should not provide a simple continuity with the surrounding society or with daily experience but must ensure a specific community dedicated to the discovery of the things using intelligence [10]. The school of the XXI century should promote the autonomous judgment and the ability to make responsible choices, addressing four particular "key-challenges" [11]: enabling students to use the knowledge they have learned, promoting not the accumulation of "inert knowledge" but the development of a "thought in action"; establish synergies between school curricula and children's media universe, promoting an education *with* the media, *to* media and *through* media; enhancing of the non-formal and informal knowledge of children as an antidote to demotivation and early school leaving; linking school education to an idea of the young person's future and to his life plan. School education should allow the future citizens to become competent persons, capable of retroact on knowledges, returning reflectively on their use and on their structure, now according to transdisciplinary parameters, now according to a critical approach (philosophical, epistemological, historical-social) [12].

As suggested by the European Council [13], we define *competences* as a combination of knowledge, skills and attitude. However, the course was designed with the awareness that in educational project, even if competences are directly related to an effective performance, they are an element of human personality: we do not work for the acquiring of a competence, but to support our student to become competent persons [2]. In this sense, we consider the competences as expression of a cultural and scientific background articulated around the ability to problematize reality, to formulate hypotheses for the solution of problems, to "learn to learn" [14]. School education should encourage deep awareness and internalized learning, elements that do not need a "review" to be shown, but that go to structure the pattern of the personal and cultural identity of our students [12].

Planning for competences starts from the individuation of the aim of the educational path, focused not only on the knowledge and skills, but above all on the ways these can be regenerated in the mind of the students, intertwining with their personal skills and with the cultural suggestions that they will have received in non-formal and informal contexts. The educational outcome is a construct through which teachers work on the awareness and learning capacities of students as significant and motivating elements. It must be inserted in a space of interaction between the meaning of the cultural object (which is known to the teacher, who has in mind the educational and formative potential) and the vital worlds of the students, by appealing to the existential and personal dimension of each of them. Once the training objective is chosen, it is possible to identify the competences to be promoted. Along the processes of the educational path, it will be easier for the teacher to grasp the "existential dimension of the person" and determine *in itinere* which areas of competence can be more easily activated. The second step is to identify the concrete and challenging situations that will accompany the entire path and that can be used to implement an authentic evaluation that puts students in front of tasks of reality [12]. This kind of element supports students in the construction of operational representations of problem-situations, in the elaboration of functional representations of complex tasks to be faced; they are representations that arise from a process of abstraction that considers only what is useful to the action [15].

3. SCIENCE CONSTRUCTION COURSE

The presented educational path is part of a three-year action-research project about the development of STEM skills during ordinary Technology school hours. The chosen topic for the course is Science construction. The teacher-researcher decided to broach the structural elements of buildings (types and forms of structures, building materials, etc.). During this pathway students used the LEGO® Education Simple & Powered machines set, without following the included instructions.

All the courses of the research project are structured following the principles of four main educational methodology [16] Media Education, Cooperative Learning, Discovery Learning and Think-Make-Improve.

In the original design, lessons were divided in four main moments (Figure 1): a theoretical phase (from 5 to 20 minutes) to provide the disciplinary knowledge to understand the experiment and formulate consistent assumptions; a process of group formulation of hypotheses following the guideline questions on the accompanying board and subsequent experiment (recorded with both accompanying board and digital tools); a final moment guided by question to build cooperatively the rule that explains the events, to reflect about the lived experience, to imaginate a possible improvement of the performance.

During A.y. 2019/20 all the 10 meeting were in presence (the courses ended the week before the starting of the lockdown in February 2020). During the first lesson (October 2019) we proposed the entrance tests and introduced the laboratory; the second and third meetings were dedicated to a theoretical introduction with regular propaedeutically mini challenge. From the fourth to the eighth lesson students approached the practical challenge (see below). During the ninth meeting the students the curricular test, designed to verify the knowledge, abilities, and competences (see section 4 Results and conclusion). The last lesson was dedicated to the exit test.

Since in September 2020 secondary school students could not attend in presence, we decided to propose the course during the second semester. We started in March 2021 proposing, as the previous year, entrance tests. Because of Covid-19 emergency, the second, the third and the fourth meeting were online (synchronous modality), and they were dedicated to a large amount of disciplinary information and to regular mini challenge propaedeutically for the following lessons. From the fifth to the ninth lessons, we proposed the practical challenges and during the last meeting students afforded the 3 curricular tests.

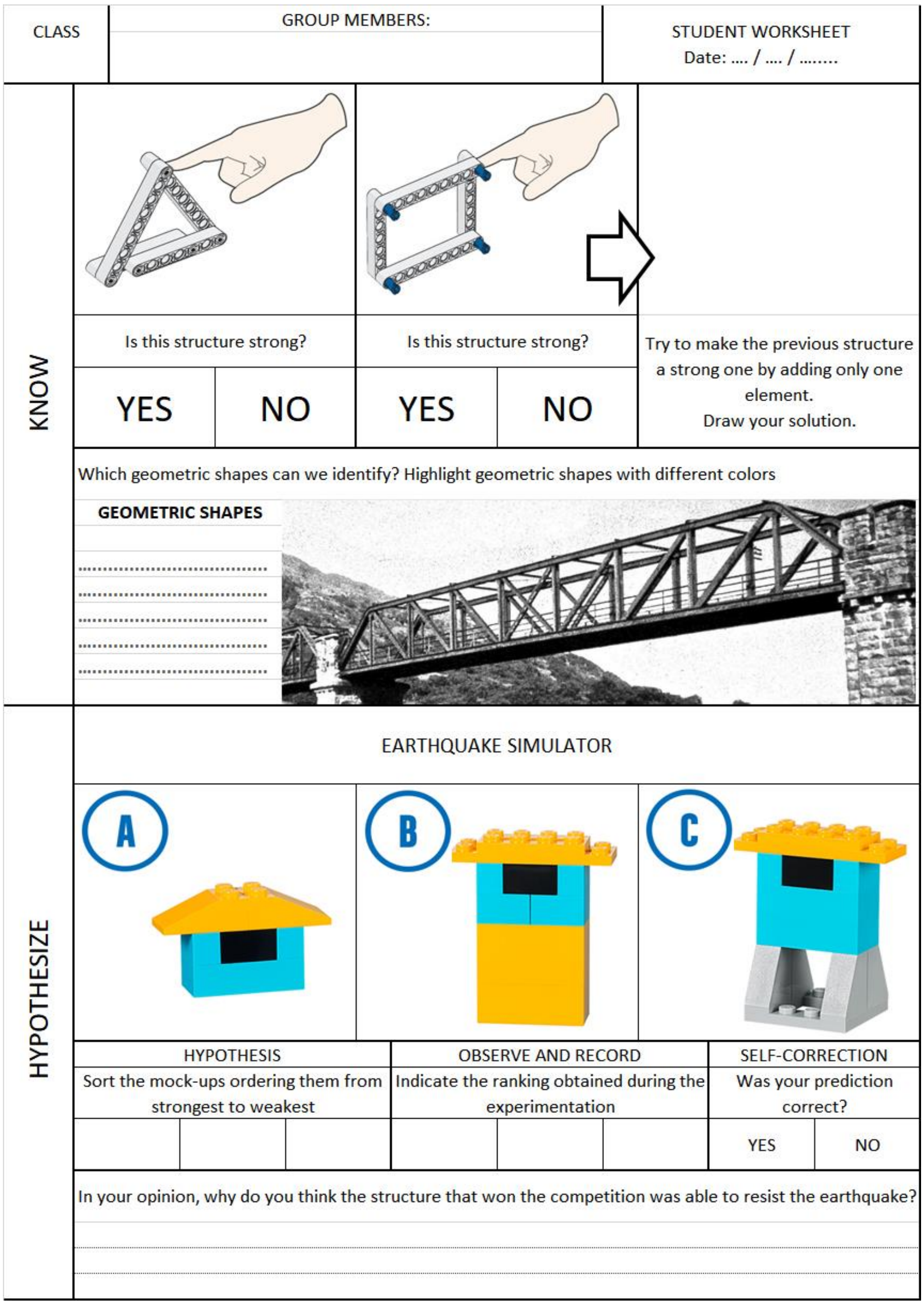

Figure 5 Example of Accompanying board

During a.y. 2019/20 as 2020/21, the researchers proposed six *practical challenges*. Five as group activities useful to understand a concept experimenting it, and one as part of the individual ability test (Figure 2).

Challenge 1. Each group must build a tower at least 20 cm high that can hold the weight of 5 school diaries

Challenge 2. Each group must 2.1. build a strong truss; 2.2. build a roof structure with two trusses

Challenge 3. Each group must build a single-storey high frame structure without diagonal elements, able to withstand the weight of 5 diaries

Challenge 4. Each group must build a basic structure which must be strengthened with diagonal elements.

Challenge 5. Each group must build a bridge that exceeds in length 20 cm and resists the weight of 15 school diaries

Individual challenge (ability test). Create a stable column/pillar. Students draw project in a dedicated space of the test and then build the model with the construction kit; they must autonomously verify the stability of the column, and then they must explain how they stabilized the building and indicate what design choices were useful to make the structure stable. Students had 20 minutes to finish the challenge.

Figure 6 Buildings for individual and group practical challenges

4. RESULTS AND CONCLUSIONS

As previously mentioned, the research group decided to collect quantitative and qualitative data all along the meetings. Regarding quantitative data, we prepared 3 tests. The first one monitors the knowledge as all the ordinary school verify; the second one was designed to estimate the capacity to solve new problems directly related to disciplinary knowledge (abilities); the third one verifies the capability to find a personal solution to a never encountered problem not directly related to disciplinary knowledge (competence).

Example of question challenge included in final tests:

Knowledge. Structured test with closed or semi-closed questions.
Indicate with an X the right answer.
O The shape of a structure determines its resistance
O The strength of a structure depends only on the materials used
O The stability of a structure does not depend on its shape

Ability. Question on the analysis of structures Insert (if necessary) the elements that make the following structural figures stable (Figure 2).

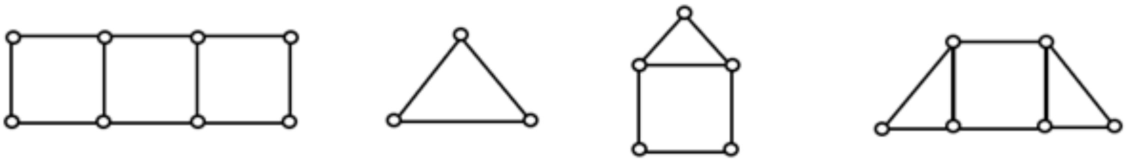

Figure 7 Example of question in ability test

Competence. Question on the structural design of a daily object
Look at the picture (Figure 3). Which of the two glasses is more stable? Why?
Are the glasses you usually use more similar to A or B? Why do you think we use that one?

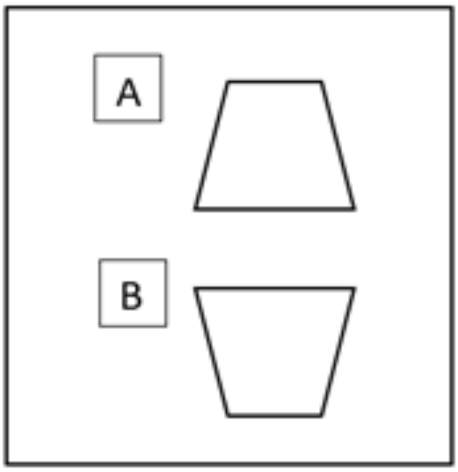

Figure 8 Example of question in competence test

We previously assigned a mathematical score to each question, and for every scoring range we assigned a curricular vote on a numerical scale from 1 to 10 (scores ≥ 6 passing grades, score ≥ 8 excellent grades, score ≤ 4 seriously insufficient grades). In two year of research the course has been proposed in 5 classes (2 during the first one, 3 during the third), involving about ninety students. At the end of both paths (Table 1):

- most of the student obtained a passing grade (82.35 % in February 2020, 87.03% in May 2021);
- half of the involved students awarded the excellent score range;
- only a small part of participants achieved a seriously insufficient rating.

Table 1: The results of the curricular tests after the courses

Y.a.	N. passing grades	N. excellent	N. failing grades	N. seriously insufficient grades
2019/20	28/34	14/28	5/34	1/5
2020/21	47/54	17/34	7/54	2/7

At the beginning of the third year of research we firmly believe that the most important qualitative data is that the proposed educational methodology has proved useful not just for the curricular goals:

All the involved students had the opportunity to participate actively to the challenges. Thanks to the presence of two researcher-teachers and, where possible, of the support teacher, every kid experimented a new learning environment conceived to pass highly complex topics in the form of game.

The class atmosphere was collaborative and non-competitive. We decided to always promote the ability to finish the challenges, without ever praising faster students differently. The best performances (not on the time level, but on the results obtained) were taken as an example not for how the group concluded the challenge, but to show how it was possible to apply disciplinary knowledge to a real LEGO construction.

The teaching methodology was used in different courses with different topics. The presented course is part of a biggest research project based on three educational paths: a training program based on LEGO® Education Mindstorms® EV3 [1], a science construction course, and a pathway about Renewable energy [16]. The researchers also used the same structure for an extracurricular laboratory about coding, electronic, videomaking, 3D modeling and printing [21]. During a.y. 2020/21 the researcher proposed the same methodology during a curricular course focused on the use of digital technologies and the processes of Scientific traditional method in humanistic subjects (history, geography, Italian, English, etc).

An interesting data about this educational path can be observed by comparing the obtained results in all the research project: students involved in the construction science courses achieved better score range in all the three tests, as groups and as individuals. We think it is very interesting because, this is the only one in which kids do not follow any instruction for the experimental phase. This data calls into question the hypothesis that the proposed educational methodology is more efficient if students have the opportunity to project personally the object of the experimentation phase.

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Numeral system, arithmetic machines and coding

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ABSTRACT

This paper presents the class practices of an educational project on the evolution of techniques and computing machines dedicated to students of the 1st year of the Scientific Lyceum and carried out both in the school year 2020-21 that in the first part of the school year 2021-22, involving a total of about 110 students. In addition to laboratory aspects linked to the history of mathematics and ancient civilizations, and during the project a lot of hours were dedicated to the creation of a "perpetual abacus" and its development in programming language, thus passing from making to coding.

KEYWORDS

"Numeral system", "coding", "making", "perpetual abacus", "Napier bones".

1. INTRODUCTION

If we take into account all kinds of invented mathematical instruments, since the Sumerian arithmetic tables (ca. 2500 BC) and from the Chinese and Greek abacuses (V - IV century BC) it can be deduced that devices to relieve tedious fatigue calculus appeared very early in the history of civilizations. The multiplication tables and the schedules were more than sufficient for the limited requirement of calculation of merchants, accountants and administrators, at least until the XVIIth century, when the scientific revolution and the growth of government bureaucracies required more complex calculations and greater precision, so much so induce the philosopher and mathematician Gottfried Leibniz to exclaim "it is unworthy that excellent men should wasting their time in calculating when any farmer could do it just as well with the help of a machine". Over the next two centuries, numerous scientists and simple craftsmen devoted themselves to the invention and construction of machines for arithmetic calculation, slowly transforming these devices from "useless toys" in useful items, mass produced and sold in large numbers.

The central idea of the project is to link the potential of the history of mathematics to laboratory teaching and coding. The mathematical laboratory has served to activate in the student harmonic processes of conceptualization of mathematical objects, an aspect that can be important to open the students' learning horizons towards past historical realities with their ways of mathematization, problem solving and formal practices, linked to the social, economic, political and cultural issues of the time. The choice to focus on learning that has been the product of the active construction of the student and which therefore has the characteristic of being situated, that is, referring to a precise social and cultural context while always remaining in relation to other contexts, has the great value of contribute to making mathematics teaching more dynamic, in step with the recent requests for the development of skills and with a view to greater integration towards a true teaching of STEM disciplines.

2. DESCRIPTION

The didactical project was realized into 4 different 1st class of Scientific Lyceum during the school year 2020-21 and also in the first part of the school year 2021-22. In both school years, the project had a total duration of 8 hours morning lessons and involved 109 students (64 male and 45 female) 14-15 years old.

During the lessons students have analyzed the history and the born of different numeral system, the mathematical notation for representing numbers of a given set and how using digits or other symbols in a consistent manner, and that same sequence of symbols represent different numbers in different numeral systems. Starting from the polynomial development of the numbers written in the most commonly used decimal system, students have known the numbering systems of ancient Egypt, ancient Rome and above all the binary numbering system (used in electronics), the hexadecimal system (typical of programming languages) and the characteristics and possible applications of the 3, 4, 5, 6, 7, 8 and 11 base of numeral systems.

The target to study different numeric system was to teach students how to transfer a number from one base to another starting from the assumption that any number in any numeric system can be represented as

$$Q_m = x_n m^n + x_{n-1} m^{n-1} + x_{n-2} m^{n-2} + \cdots + x_1 m^1 + x_0 m^0$$

where

- Qm is a combination (integer), such as a number in base value m;
- x is the digit (0 – 9 for base 10 system, 0 and 1 for binary system);
- m is the base value (10 for base 10 system, 2 for binary system).

To convert numbers, student used the successive subtraction method with the help of an artefact created by the teacher and called "perpetual abacus" (see Fig. 1). This particular abacus allows the direct transformation through from another numbering system to the decimal one through the reading of the polynomial writing of the number, the conversion from the decimal base to all the bases from 2 to 16 through the successive subtraction method of and the possibility to modify the base, as well as the conversion from any base to another (passing from the decimal base). The simplicity of the use of this abacus, much appreciated by the students because it can be manipulated, has allowed the introduction of the writing of numbers in many other numbering systems and has inspired some students to recreate this abacus in digital format by translating the algorithm of the successive subtraction method in Excel and in block language.

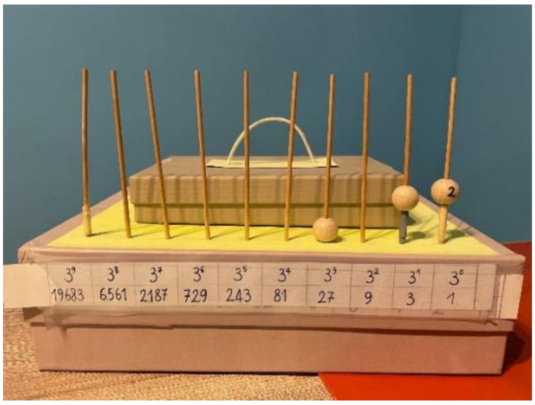

Figure 9: Perpetual abacus whit insert the base value 3

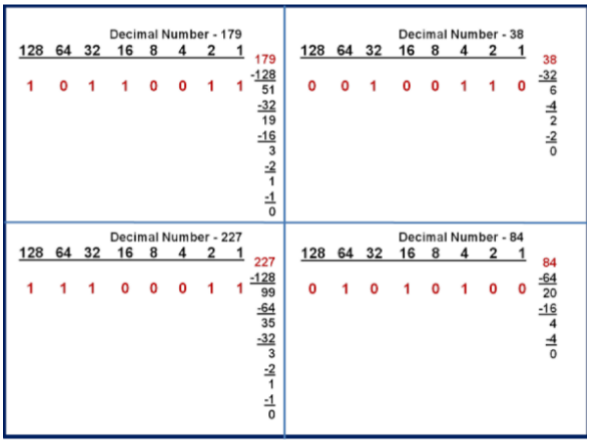

Figure 10: number conversion in binary system whit successive subtraction method

The didactic time savings were used to talk about the history of automatic calculation machines and in particular we talked about Napier's bones. Napier's bones is a manually-operated calculating device created by John Napier for the calculation of products and quotients of numbers. In their simplest version, the Napier's bones are sticks, on each of which the first multiples of a number are engraved, with the tens and units divided by a oblique bar. By combining the sticks corresponding to different digits to compose a certain number (for example by combining the sticks for 2, 4 and 6 to compose "246"), and adding the adjacent digits (not separated by the bar) in the different rows, you can easily obtain the multiples table of the number in question. So they can be considered as a generalization of the multiplication table. The principle on which they are based was already widespread in Mediterranean countries with the name of lattice multiplication, also called "Venetian squares" or "rabdology", a word invented by Napier in 1617. This method has been used for centuries in many different cultures and it is still being taught in certain curricula today, such as in Singapore. Napier's bones were added, with small variations, to many arithmetic machines in order to transform them into "multiplying" machines. Examples range from Wilhelm Schickard's machine (1623) to J. Bamberger's Omega (1905)

Let's explain this method better. The two multiplicands of the product to be calculated are written along the top and right side of the lattice, respectively, with one digit per column across the top for the first multiplicand (the number written left to right), and one digit per row down the right side for the second multiplicand (the number written top-down). Then each cell of the lattice is filled in with product of its column and row digit.

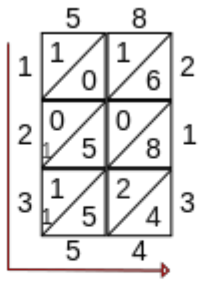

Figure 11: the product 58 × 213 using Napier's bones

As an example, consider the multiplication of 58 with 213. After writing the multiplicands on the sides, consider each cell, beginning with the top left cell. In this case, the column digit is 5 and the row digit is 2. Write their product, 10, in the cell, with the digit 1 above the diagonal and the digit 0 below the diagonal (Fig. 3). If the simple product lacks a digit in the tens place, simply fill in the tens place with a 0. After all the cells are filled in this manner, the digits in each diagonal are summed, working from the bottom right diagonal to the top left. Each diagonal sum is written where the diagonal ends. If the sum contains more than one digit, the value of the tens place is carried into the next diagonal. Numbers are filled to the left and to the bottom of the grid, and the answer is the numbers read off down (on the left) and across (on the bottom). In the example shown, the result of the multiplication of 58 with 213 is 12354.

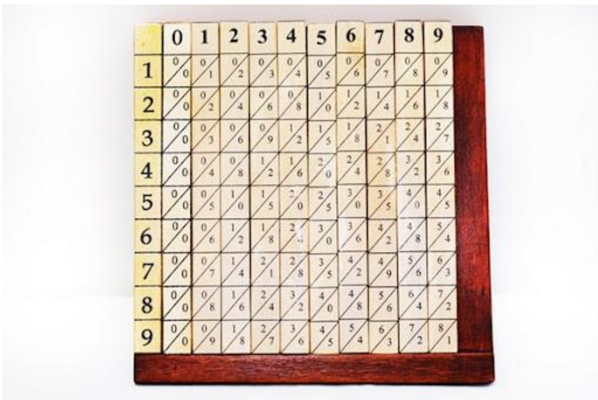

Figure 12: wooden Napier's bones

The students built theirs using both cardboard and wood (Fig. 4) and learned how to multiply numbers with the lattice method. This technique was particularly inclusive towards DSA students who have known a new way to overcome their difficulties. Some students who are particularly enthusiastic about this new calculation technique have sought information and built the evolution of Napier's bones, that is, the Genaille–Lucas rulers learning how to use them for multiplications and analyzing affinities and differences with Napier's bones.

3. CONCLUSION

Combining laboratory teaching and the history of mathematics offers the opportunity for integrated teaching between disciplines and to implement multidisciplinary and interdisciplinary thematic approaches, but at the same time it allows us to discover that obstacles related to mathematics have been overcome even after thousands of years of use, studies and research, thus rehabilitating and enhancing errors in the didactic process of mathematics. The idea to realize math artefacts on to the history of mathematics expanded curiosity and developed pleasure of learning in students, and has helped them to forget the traditional belief that mathematics is a static, ahistorical discipline, defined in itself always the same, made up only of definitions, formulas, operations.

The project has aroused a lot of enthusiasm in the students and it is therefore my intention to replicate it in future with the target to study and ask to realize to my students other arithmetic machines in addition to the evolution of Napier's bones in other numeric bases and also the deep study of Genaille–Lucas rules, with the ambitious aim of make some computing practices more inclusive for DSA students.

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BIOS

Matteo Torre was born in 1984. After graduated in Mathematics (with a thesis on the teaching of quantum mechanics) immediately began his career as high school teacher. At the same time he carries on his passion for the teaching of physics and mathematics: he become in 2010 research fellow at the University of Pavia (in the History and Didactics of Physics) and obtain a Postgraduate Course and a Master in Physics Didactics. Didactic consultant of science teaching associations, he is author of 80 scientific papers and 8 books on science popularization. His latest research concerns the use of history and philosophy of mathematics and physics for the development of basic scientific skills.

Ulisse on the road. From book to digital storyboards. Program for primary school.

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ABSTRACT

This paper describes the main phases of an instructional design activated in a fourth class of a primary school in province of Turin. The focus of the project is the short cartoon production by the students as a reworking of the narrative text of the *Odissea*, with digital storyboard webapp and dubbing app.

KEYWORDS

Digital storyboard; Odissea; primary school; audiovisual product.

1. DESCRIPTION

1.1. Description of the setting

The school where the didactic design was implemented is part of an institute of the province of Turin. It is characterized by a heterogeneous user from the socio-cultural point of view. The class group consists of 22 pupils, of whom one is a second-generation foreign pupil and two pupils with special educational needs in the process of certification of specific learning disorders. The design was born, therefore, precisely to respond to this high degree of heterogeneity of the class group, with the aim of exploiting the different communication codes involved in the activities to offer an inclusive proposal in accordance with the principles of universal design for learning. In this regard, the apps to create digital storyboards are a very good tool of inclusivity both for students with specific learning disabilities and for non-Italian-speaking students Also, the central theme, the journey, was chosen to respond to the heterogeneity of the class group to problematize and reflect on this issue in an intercultural key inferring it to their personal experience and to historical and contemporary migratory phenomena.

The design, therefore, meets the following training needs:

- Strengthen the communication function in reception,
- Enhance the ability to critical reflection on a narrative text,
- Increase the ability to rework a text using multiple channels and communicative means,
- Re-elaboration of current behavioral models in relation to values extrapolated from heroic feats narratives.

1.2. Description of the educational experience

The instructional design is aimed at strengthening of the literacy skills, so the expectation is that at the end of the design the pupil understands, interprets, produces elaborations of narrations implementing communicative choices aware of the request and the target audience of the action. Other related key competences are the digital competence, awareness, responsibility in the use of technologies to research, produce and process data and information, to interact with other people, to creativity and problem solving; and express and communicate, realize productions of various types, using different techniques, materials, tools. This is a cross-disciplinary design involving mainly Italian, art, geography, technology. The choice to deal with a topic such as the *Odissea* at primary school assumes that there are no contents that cannotbe treated in certain school orders, because it depends on the way in which they are treated even though it is often thought that children do not have the maturity to deal with certain topics.

The focus of the project is the production by the students of an audiovisual product as a critical and contemporary reworking of the narrative text in children's version of the Odyssey. To produce the cartoon is required the synergistic use of paper resources, children's prose versionof the text and comparison with some original verses of the poem, and digital, multimedia content production applications and search engines such as Wikipedia. In particular, the design includes the use of the application *StoryboardThat*, open-source, used to structure the digital storytelling of the work; Audacity, free application for voice acting characters and Imovie for installation. The reading of the opera took place in moments of shared listening in the classroom. In addition to the activities aimed at the realization of the final product of digital storytelling, various proposals have been made on issues of education to citizenship including: the journey, associating the figure of Ulysses to our heroes of everyday life; the cultures and figures of women in different civilizations, starting from the analysis of Greek civilization. There is an important work of inference of sources and triangulation of geographical and geohistorical maps, through the geographical analysis of the stages of the journey of Ulysses relating them through Google Earth to the current geographic sites and reproducing the journey on the Google Earth application. The project includes several working moments in cooperative learning and an active participation of pupils in the construction of the learning path through the production of research and the use of different ICT for the creation of interactive presentations.

The activities were carried out both in the presence and in e-learning mode. The teachers have prepared the classroom according to the proposed activities and the methods chosen. The classroom space has been made flexible to allow the teacher to prepare setting for the performance of laboratory activities or circle time and cooperative learning, so sometimes the arrangement of the banks was islands, sometimes to stations and sometimes the benches were moved for activities where more freedom of movement was required. It was considered necessary to provide moments of social study, collaborative and individual in synchronous and asynchronous modes, in virtual and real spaces. Besides the resources already mentioned, those used are: reading book, structured material, classroom, learning apps, structured evaluation tools.

The activities have been structured in four macro areas (Castoldi, 2020), whose activities are summarized in Table 1 and Table 2: Sharing of meaning, training, match and reflection.

Table 1

FASI	TEACHING IN THE PRESENCE		
	TIME	ACTIVITIES	METHODS
SHARING OF MEANING	2	EXPLORATION OF THE ARGUMENT Teacher guide thepupils in formalizing and socializing the foreknowledge of the class group.	Brainstorming, cooperative Learning
	1	PROBLEM SITUATION	Circle Time
TRAINING	2	DRAMATIZATION children are dividedinto pairs, each coupleis provided with material about a Greek deity that will have to be presented in the form of dramatization to the companions	Peer education

	1	FUN ACTIVITIES Teacher, to monitor the degree of knowledge acquisition on the deities treated, divides the class into two teams and proposes riddles with different clues and degrees of difficulty. The same activity is repeated on Nearpod.	Game-Based Learning
	2	BOOK READING Teacher reads thebook withsome pauses of interaction.	Circle time e Debate
	2	GUIDED REFLECTION ONTHE ROLE OF THE HERO	Circle time, debate, metacognition cooperative learning
	2	GOOGLEVS GEOHISTORICAL MAP Identification of the stages of Ulisse journey on the geohistorical map; search, identification and re-production of Ulisse journey on Google Earth	Small group learning
MATCH	4	CARTOON PRODUCTION Class is divided into groups; each group is assigned a chapter of the book. Each group will have to share the roles (director, screenwriter, voice actor...) and produce through the application The story board that the storyboard ofthe story, produce a task, edit the video with Imovie and dub the characters through Audacity.	Small group learning structured, peer to peer.
REFLECTION	1	DEBATE initial expectations vs real contents of the story	Circle time, debate
	2	Socialization of experience with other classes.	Peer education, self-evaluation

Table 2

E-LEARNING			
SHARING OF MEANING	ACTIVITIES	TEACHING METHODS	WEB TOOLS
	EXPLORATION OF RESOURCES DIGITAL experimentation ofthe application that will come used StoryboardThat	asynchronous and individual	Classroo, StoryboardTha

TRAINING	Vision of the video "The myth of creation according to the Greeks" and creation of a digital conceptual map to socialize with class group in attendance.	Group asynchronous (Cooperative Elearning)	Classroom, Youtube, Presentation Google Drive
	Research in groups on Homer and Trojan War and design presentation Power point from present to the class	Synchronous and Asynchronous in groups	Wikipedia, Google, Google Drive, Classroom, Youtube

2. CONCLUSION

2.1. Results

The students expressed a strong interest in the design, proposing themselves the study of the geographical locations of the stages of Ulysses. It was considered relevant to take these cues from the perspective of a flexible design and open to the training needs of students. The use of Google Earth has given rise to a reflection on the changes that these territories have undergone both physically and geopolitically. At the same time, students often presented themselves in class with material to share with their classmates, such as the statue of the Trojan horse currently present in Turkey. On many occasions, compared to the expected, further ideas for dialogue emerged, such as the one on the role of women *Because it is the son of Penelope who must decide if the mother should marry, she could not decide herself?* The intervention was accessible to all both in terms of resources and for the learning experience. Before the didactic intervention, in fact, I made sure that everyone had access to at least one digital resource in the domestic field. As for the learning experience, accessibility lies in multimodality, I tried notto propose differentiated activities to children with Bes, as the meaning of the work was to find a mode of communication that could reach everyone, and this was also the shared goal of the final product. In view of the Universal Design for Learning, which I consider very valid, I decided to implement an intervention that uses a multiplicity of communicative codes so that each student could choose what preferred. The ongoing feedback obtained during the lesson through comparison and debates gave me the opportunity to monitor its accessibility.

In addition, I noted that the non-native Italian-speaking child participated very actively and was among the students who achieved one of the best results in dramatization and dubbing of the characters as this mode allowed him to identify with the and facilitate their understanding. The final product was also to the satisfaction of both the pupils and the families to whom it was presented through a meeting at the end of the project. I believe that it is essential, by virtue of the educational pact that takes place at the beginning of the year, to share these products and, more generally, projects with families. One of my goals was also to provide stimuli and input to see which were taken by children and at the same time give them a way to customize the experience by doing insights on what they considered most interesting. Interesting are the thoughts of the students, on how much this work would not have reached completion without teamwork or on the opportunity of learning provided by the insights of the peer group, feedback that goes perfectly with the concept of co-building the experience that I wanted to promote.

2.2. Broader Value

My design started from a theoretical reflection on the definition of learning environments. The concept of learning environment cannot be reduced to a spatial organization, it is a much more complex concept characterized by the set of methodological and relational choices of the teacher. This implies that methodologies close to the Scuola senza zaino, for example, can also be activated in those classes with furnishings defined "traditional" and this can only happen through the choices of the teacher. An inflexible physical environment, if properly deconstructed, can become a flexible learning environment responding to the multiplicity of educational needs present in the classroom. This is what I tried to accomplish with my design, implement methodological choices that would make the student participate and active builder of experience, freeing him from the binding space of the bench, reconstructing their learning environment in an original way. I considered it necessary to reflect on what was meant by DDI, I often think there is a misunderstanding of thinking that this consists in the alternation between distance teaching and teaching in the presence. I believe that this is not just about this, activating an integrated digital teaching means using multimode digital tools during the different educational activities in the presence and at a distance, reworking the traditional notion of school time, providing synchronous and asynchronous activities in both cases. I therefore considered it essential to document, before implementing my experimentation, on the Piano Nazionale Scuola Digitale proposed by the Miur in order to adapt as much as possible to my design, because I believe that teachers must be constantly updated and that educational and educational choices must also be developed on the basis of new scientific discoveries and social and bureaucratic advances, because otherwise there is a risk that society will progress and the school remains a step backward in the transformation process, going to create a dystonia in the transformation process. The choice to deal with a subject such as the Odyssey at primary, can be said provocative in the terms in which it was proposed precisely for the purpose that there are, in my opinion, content that cannot be treated in certain school orders, but it all depends on how they are treated. It is often thought that children do not have the maturity to deal with certain topics, relying on social stereotypes and anachronistic from my point of view. With this design I noticed that children have a lot to say and often propose content that I had not planned to touch in the design, for example, the role of women in different societies, resulting in current events.

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BIOS

The design was conceived and activated by the undersigned, Fabiana Barone. I am a primary school teacher, graduated in primary education sciences. During my university career I studied and conducted media education experiments in primary school, to date I am an independent researcher with particular interest in virtual learning environments and the use of new media in different information contexts.

On my site http://www.fabianabarone.com/ it is possible to view the projects and products made with different primary school classes

Cooperative methods, use of digital tools and lifelong training: a way to move forward during distance learning

Anna Crespiatico

ABSTRACT

Cooperativa Pandora is an Italian social cooperative, a private non-profit enterprise that deals with education in formal and non-formal contexts. Its work is aimed at students of Italian primary and secondary schools (aged 6-19), children and adolescents in informal and non- formal educational contexts (eg summer camps, community workshops, etc.), even in contexts of educational poverty. Our work is also aimed at teaching staff and educators with training courses in cooperative teaching. It carries out its work in three regions (Lombardy; Piedmont; Liguria), in particular in the cities of Milan, Brescia, Turin, Genoa and their suburbs. Cooperativa Pandora uses cooperative methods in its educational activities with the aim of identifying, designing and testing good practices for classroom activities in order to enhance the different skills and competences of the class group, with an interdisciplinary approach. In this paper we want to describe an ongoing program: the combination of our cooperative approach and digital tools, which has been strengthened, speeded up and spread among all colleagues of the cooperative thanks to the challenge offered by distance learning. This was possible thanks to a rapid reorganization of our way of working, in order not to interrupt the didactic activities with the classes and thanks to a strong investment in the training of educators. The most important lesson that Cooperativa Pandora wants to share with fellow educators is the importance of lifelong training and the importance of self-training processes within the team of educators in a cooperative perspective, exchanging skills and good practices with a pro-active approach to promote "bottom-up" didactic innovation processes.

KEYWORDS

"Lifelong teachers training" "New learning model" "Secondary school" "Technology in learning and teaching"

1. DESCRIPTION

1.1. Description of your setting

The educational setting we work in is primary and secondary school: we work with students aged 6-19, in three regions (Lombardy; Piedmont; Liguria), in particular in the cities of Milan, Brescia, Turin, Genoa as a team of facilitators, educators and trainers.

Our work is also aimed at teaching staff and educators with training courses in cooperative teaching. We use cooperative methods in our educational activities with the aim of identifying, designing and testing good practices for school activities in order to enhance the different skills and competences of the class group, with an interdisciplinary approach. Our cooperative is a social cooperative born in 1996; we are a group of 30 colleagues, with different specializations: we are educators, youth workers, pedagogists, psychologists, counsellors.

Our experience in schools of all types and levels involve pupils aged between 6 and 19 with cooperative education activities. Our most relevant projects are "GIOCOOPERIAMO" (age 6-11), COOPERARE PER UNA CITTADINANZA ATTIVA (12-15) and BELLACOOPIA (16-19).

We provide training courses for teachers and educators about cooperative teaching. The training proposal starts from the consideration that cooperation, if used as a teaching practice, can be an effective method of solving problems, activating learning processes, enhancing different skills from an inclusive perspective and assuming responsibility.

The cooperative approach we refer to as an organization does not follow the Learning Togheter codified by Johnson & Johnson in 1975 or other models such as the Student Team Learning (Slavin) or Kagan's structural approach to Cooperative Learning; we are interested in these methods, but we prefer to use some of their techniques, such as the Jigsaw technique (Aronson; Slavin), combining them with our methodological cornerstone, "learning by doing", with references to Dewey, Freinet, Mario Lodi and the Movement for Educational Cooperation (MCE). A reference to our method can be found in the chapter " La didattica del fare in Bellacoopia " (pp. 97-125) in “Teaching the cooperative enterprise. Bellacoopia: an experience of communication with school”. The educational experience of Bellacoopia, made possible thanks to the support of Coop, Legacoop, the collaboration with La Bella Impresa and our educational expertise, is based on developing with students a business idea in a cooperative way.

We work in schools of all types and levels, we use various cooperative teaching tools with the aim of identifying, designing and experimenting good practices for activities in order to enhance the different skills and competences of the class group, with an interdisciplinary approach.

Our workshops and activities aim to enhance the participation of pupils; we believe in a collective and shared growth process. Cooperative learning, in fact, does not configure as a simple group work method, but goes further, transforming any critical elements into opportunities in order to guarantee:

- The enhancement of each individual participant in the group
- The assumption of individual responsibility for the achievement of a common goal
- A pleasant and welcoming atmosphere
- The development of social skills

In our vision a cooperative approach aims to build well-being at school or in learning situations. The method refers to the Ministry of Education guidelines: it aims at "Strengthening the development of key competences" (in line with the Recommendation of the European Council on key competences for lifelong learning) in order to foster creative and innovative learning approaches, promoting interest in complexity and, on the other hand, strengthening the ability to activate individual skills thanks to learning by doing, that allows to acquire knowledge in a direct and participatory way. Learning by doing and learning in a group develop an active attitude to information and notions, increases the pleasure of knowledge, promotes inclusion and participation by bringing out new skills, interests and talents.

1.2. Description of the educational experience

During the Covid-19 pandemic we were able, as a working group, to continue remotely our activities based on cooperative approaches, combining them with the use of digital tools (devices, web-based applications).

With the arrival of the pandemic in February 2020, a total transformation of our activities became necessary, in order to continue to carry them out remotely with the classes. We operated with remote self-training mechanisms to react to this sudden request for change, mediated by the digital tools and applications already used by some of us. These self-training activities were implemented in a cooperative way, to simulate the mechanisms we were going to propose to students. Our aim was to try to keep cohesive our group of educators.

Phases of our self-training activities:

- Enhancement of the different skills already present in the team: colleagues with good digital skills have set up the first stages of digitizationof the paths (choice of the most suitable digital tools, early stages of readjustment)
- Enhancement of training activities: colleagues with good digital skills have transferred them to other colleagues through numerous remotetrainings. During the training sessions between colleagues, the cooperative methodology and learning by doing were used.

- Enhancement of the new digital skills acquired, dividing the digital re-design of our activities on a large group of members of the workinggroup and no longer only on those who already had a good level of digital skills, who took the role of supervisor of the activities and of the digital products created

- Enhancement of other skills in colleagues with longer learning times in the field of digital and technologies: they wrote texts and research materials to create toolkits for schools

- Enhancement of supervision between colleagues, with the use of interactive activities to promote group cohesion and the inclusion of all members.

A further investment in our training activities was made through the participation in numerous webinars on the topics of digital teaching by Prof. Maria Ranieri of the University of Florence, which have expanded the number of notions and skills available to us.

Over time, our Cooperative has participated to training activities and lived experiences that have made possible to reinvent in a digital way our activities and workshops for schools, combining our cooperative approaches to the use of technologies. Here is a short chronological sequence of our learning stages as a team:

1. 2013 - Training on the use of digital tools in educational activities, held by Paolo Gallese. Topics: Use of Symbaloo, Prezi and interactivePowerpoints.

2. On the occasion of EXPO 2015, we have been asked to design the digital content and to manage the educational activities in "Aula del Futuro - Food District", an educational area set up on behalf of Coop. The design of content in a digital form required a few demanding months of work for us. During the six months of the exhibition, we daily managed groups of pupils aged between 6 and 19, families and free adult visitors, both Italian and foreign, proposing them educational activities on sustainability issues based on the cooperative methodology and the use of digital tools. The digital tools used were multimedia interactive whiteboards connected to individual devices. All activities were designed by us with Promethean's Active Inspire software in strong collaboration with C2 Group.

   The activities were designed to be proposed according to the so-called model “Classroom 3.0”, conceived by Indire and the Avanguardie Educative Movement

3. This experience has allowed us to understand how digital tools and devices, software and web-based applications could be useful in combination with the cooperative approach that has always characterized our activities; however, we wondered how to re-enact the cooperative activities experienced in a learning environment as particular as “Classroom 3.0” which is not present in many of the schools wework with.

4. We developed a method that took inspiration from what we learned from the experience of Expo which include the use of the interactive whiteboard, of Padlet (web-based application) and of the available devices (computers in the computer lab, students ‘smartphones) combiningthem with our traditional educational proposals.

5. In the five-year period 2015 - 2020 this approach was chosen voluntarily by the educators who felt closest to this modality.

6. The pandemic and the request for distance learning in February 2020 were a catalyst for a total revision of our activities in order to continueto carry them out remotely with students.

The distance learning experience has led us to a structured combination of our cooperative approaches and the use of digital tools. All our projects now contemplate the systematic use of Padlet and other web based applications such as Mentimeter, Kahoot, Canva and Google documents. Our most important experience was with the students at the secondary school with the project called “BELLACOOPIA”: we developed business ideas in a cooperative way, giving life to numerous class cooperatives. *(In 2020, we worked with 62 classes - source: Cooperativa Pandora social report.)*

I will use as an example this work, carried out together with the students and the teachers at the Lotto Institute of Trescore Balneario, Bergamo[11]. In the FINAL WORKS column, it's possible to find the final result produced bythe students.

The project began with a brainstorming about COOPERATION, realized with Mentimeter and with some materials dedicated to the history of cooperation, prepared by us educators. We presented the different types of existing cooperatives and the students had to decide what theywanted to create. We did several votes with Google Forms and students and teachers decided to create two cooperatives to manage a farmland confiscated from the Mafia. Each student proposed a name for the cooperative, choosing from the numerous names of Italian innocent mafia victims and created a logo using Canva. The two proposals considered most interesting by the students were voted with Google Forms: the "Rosario Livatino" cooperative, which manages a restaurant and the "Luisa Fantasia" cooperative, which grows agricultural products. At this point of the project the group work began: this allowed, despite the remote working method, to keep alive the aspects of cooperative learning and learning by doing, very important to keep students active and interested. Each group began to work on different aspects of the cooperative: communication aspects, creating the “elevator pitch” or the site, economic and managerial aspects, carrying out the swot analysis or parts of business plans, operational aspects, creating menus for customers and so on.The work was co- designed with the teachers from an interdisciplinary point of view: each teacher supported the groups in drafting the texts, in Italian and English, in the IT work, in the parts dedicated to economic or creative aspects. The work ended with a presentation to other students, in peer education mode, of all the work done. The students, despite the remote working modality, were therefore able to put their different skills into play: a mix of communication, relational, creative and technical skills.

Their feedback was very positive, for example:

Alessia “I think that distance learning has greatly disadvantaged us, even if I must say that given the situation a great job came out. Having us work in a group, in my opinion, was the most suitable thing, not only to deepen the knowledge with our classmates (since for the past year there have not been many opportunities) but also to let us realize how important cooperation is. One of the things that intrigued me more than the others was the design of the logo: we used Canva, a completely new site for me.”

Luisa “I must say that her explanations have always been interesting: Anna has always looked for a way not to bore us and I appreciated this very much: it is not always taken into consideration. She has always explained her concepts in an interesting way, for examples through quizzes, videos or even through keywords that she put in a map.”

Nada “In addition, although the meetings were carried out via computer, I found the activity very engaging, and the expert prepared and capable of attracting our attention. I also liked the working methods that she decided to adopt, such as: the use of interactive applications, videos and group work. This PCTO project allowed me to broaden my knowledge and deepen this important issue”

2. CONCLUSION

2.1. Results

Thanks to the use of digital tools in combination with our cooperative methodology, the students were able to complete the workshops, whichalso had value for the Paths for transversal skills and orientation. (PCTO). Their feedback was often particularly positive: they appreciated the interactivity of the lessons, the fact that they could still carry out group work using the potential of Google Meet or Teams, the possibilityof using skills and creativity and having fun with cooperative games in a difficult situation.

For us educators, the positive feedback from both students and teachers has been a great incentive after a very intense and demanding periodof work, training and self-training. We have learned the importance of lifelong training and the importance of the exchange of skills as a working group.

[11] https://padlet.com/cooppandora3/coopialotto (Ver. 13/04/2023)

Several teachers thanked us because, during our distance activities, they were able to learn the use of some digital tools and applications simply watching us at work.

2.2. Broader Value

The key learning we want to share with the broader community at FabLearn is that is fundamental, as educators, to consider the importance of training and self-training mechanisms as a working group and the importance of exchanging skills between more and less experienced colleagues. The exchange between colleagues, teachers and educators generates innovation.

The innovation of teaching is a process of *social innovation*, generative of change for a new school model, according to the idea that innovation is achieved "through experimental research since it is" in the experimental development "that there is" a systemic work designedon the knowledge learned through research and practical experience (…) ». Educational innovation is also related to the use of digital tools.

The pandemic has brought with it opportunities for innovation, as well as great difficulties, both for teachers/educators and students. Thinkingto the group of colleagues in a cooperative perspective, in which everyone works to achieve a common goal, promotes learning and students'well-being: this is what we have learned and what we will continue to work on.

2.3. Relevance to Theme

Our submission fits in with the conference theme because it talks about lifelong educators training, new learning model and technology in learning and teaching.

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BIOS

Anna Crespiatico; Educator, Coordinator, Member of the Board of Directors at Pandora Social Cooperative. In 2011 I was hired as a permanent member of the team, in 2013 I started coordinating activities for the provinces of Brescia, Bergamo and Cremona, in 2015 I joined the Board of Directors.

All the activities in which I operate are based on learning by doing and on highly participatory methods. The most significant projects I took part to were:

EXPO 2015, design of digital contents and direct management of the activities in the "Aula del Futuro - Food District", an educational area setup on behalf of Coop.

EXPO 2015, Management of the educational activities, for the Summer Camp and the Summer School organized by the Ministry of Foreign Affairs and International Cooperation; the activities were carried out with a cooperative methodology, with the use of digital with hands-on activities.

2017, development of the debate "Processo allo sviluppo insostenibile" with the classes of two high schools in Syracuse, on behalf of Cesvi, ActionAid and Aics. The classes were called to cooperate with each other, albeit in different institutions, for the construction of a simulated trialon the issues of unsustainable production and consumption. The work was carried out thanks to digital collaborative tools.

2011-today, planning and conducting activities based on the cooperative methodology and learning by doing for Saperecoop, the Conscious Consumption Education area of Coop Lombardia: every year I meet hundreds of children and young people (4-19 years) with workshops on theissues of environment and sustainability, citizenship and territory, nutrition and health. With older children (16-19 years) I also play the role of tutor for PCTO area projects for the development of business ideas in a cooperative way/development of a class cooperative.

CODING

Coding e computational thinking: understanding and constructing reality through multi perspective methods and tools.

Analysis of transversal skills acquired through game-learning

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ABSTRACT

The technological progress of the last two decades has profoundly changed our life. The world of research and work have become inextricably linked to scientific and technological progress, quickly becoming dependent on it. Inevitably, educational structures have also been characterized by these changes, adapting their teaching methods to the new tools available. Indeed, technology, associated with strong targeted programming, accelerates the learning time of complex topics. In this article we show how at the Digital Education Lab, the choice to exploit technology and game-learning methods has led to excellent results with respect to the learning of scientific concepts by primary and middle school students.

KEYWORDS

Technological learning, game-based learning, digital education, programming, Minecraft Education Edition, Microsoft MakeCode

1. INTRODUCTION

The reality we live in is dominated by scientific progress and technological development. The use of computers has favored rapid scientific growth guaranteeing the possibility of simulating complex systems [1-2], thanks to their optimization and to the validation of theoretical aspects not previously tested. The technologicalization of reality has also affected the world of education. A few decades ago, the study of the suitability of technological tools was part of the educational rationale, now the use of technology has become a tool through which to approach the study of more traditional subjects, from classical to scientific ones. In the two years between 2019 and 2021, this process was accelerated by the pandemic linked to the spread of the Sars-Covid19 [1] virus which made it necessary to close schools and educational institutions. At this juncture it became essential to use the computer as a tool to run the lessons. Reports show that while university students benefited from remote learning, younger students instead cited the lack of direct contact with teachers. This phenomenon is linked to the attention span that student of various age groups has. Older children are able to separate the ability to focus on gestures and therefore on the person; younger children associate attention with gestures and therefore with physical presence. This immature ability in the youngest students can be overcome by introducing a playful dimension. Indeed, the relationship between students' ways of processing information and education plays a fundamental role in students' learning [3]. Studies repeatedly show that learning depends on many factors [4], the most important of which are the playful [5] and the social aspects. Their combination produces faster and more concrete learning. The Digital Education Lab, a technological education school in Rome (Italy), has developed an educational method of mathematics, geometry and computer science based on the use of the gaming software *Minecraft Education Edition*. The school has developed three main educational programs based on age groups. Previous work analyzed the learning outcomes of the first course [2] (basic course for age group 8-10). In this paper we describe the learning outcomes of students aged between 11 and 13, contextualizing it within the school's didactic planning.

2. LEARNING OF DIGITAL EXPLORERS

The Digital Education Lab aims to educate its students in the conscious use of technology and the study of scientific subjects through the experience of game-coding [6]. The software used is Minecraft Education Edition. This was developed with the idea of maintaining total freedom of creation and thinking but channeling these intuitive flows into rational logics through the structure of the game reality. The Minecraft world is a cubic geometric reality, and building in Minecraft, even before the coding aspect, means being able to do medium-complex geometric reasoning [7]. The school elaborates educational paths according to the age and skills set possessed. In one of our previous articles, we described the general structure of the training courses, which is briefly summarized in Figure 1.

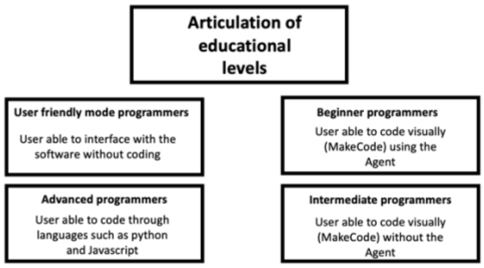

Figure 1: Schematic of the articulation of educational levels elaborated by Digital Education Lab. The educational levels have been conceived mainly on the basis of the previousskills possessed by the students of the school.

In this paper we focus on the intermediate course, which involves students aged between 11 and 13 years of age (*Digital Explorers)* and belonging to the Beginner and Intermediate Programmers.

Educational activities at Digital Education Lab are based on the use of the Minecraft Education Edition game. This game-software allows teachers to shape an educational path based on increasingly complex concepts that are stimulated through precise game situations [8]. Alongside the social and playful dynamics, students learn the fundamentals of coding, becoming familiar with the *Make Code* environment, a block-graphical programming language developed by Microsoft. *Digital Explorers* are students who already have a basic knowledge of the Make Code language, either by having followed the basic course at Digital Education Lab or preparing privately. The educational path and didactic objectives are summarized in the following three tables. The fundamental aim of the school is to develop knowledge and technical skills. This is achieved through various game modes and through direct interaction with other classmates, which takes place inside and outside the game through communication software such as Microsoft Teams. The second aim is the growth of the person, Tab. 1: game-software learning has shown a strong effect on children's developing awareness of identity. Moreover, multiplayer mode favors integration with others, favoring self-motivation and the motivation of others. The third macro-objective of the school concerns the construction of a technological conscience, which means being able to recognize favorable situations or cyber dangers. Students who follow a digital education program seem to respond more consciously and autonomously.

DIGITAL SKILLS

Didactic objectives	**Expected results**
· To develop the ability to code, using visual coding language	· To develop complex algorithms using graphical programming software such as makecode
· To undestand and apply the analysis-design-development cycle of a software	· To undestand and use the concept of function (e.g the wall can be used to make a house. A house can be used to build a whole village).
· To develop analysis and problem solving skills (debugging)	· To conceive, structure and implement complex projects within the game world through the use of programming.
To undestand and use the concept of process archetype	· To analyze the code writtend by others and make any corrections.

Tab 1 Summary of the technical and digital skills expected to be acquired by the end of the Intermediate Course.

GROWTH AND PERSONAL DEVELOPMENT

Didactic objectives	Expected results
· To develop system thinking.	· To analyze small and medium complexity problems through systemic thinking.
· To develop computational thinking and problem solving	· To solve problems of small and medium complexity, through computational thinking.
· To develop self-control, awareness, flexibility, critical thinking, self-motivation, ability to motivate others.	·To self-motivate and motivate
· To develop empathy, gratitude and self-evaluation skills	·To develop empathy, gratitude and the ability of self evaluate.
· To encourage creativity and develop the ability to create and describe results.	To create and tell a story, also through the use of digital tools.

Tab 2: Summary of the growth and personal development expected to be acquired by the end of the Intermediate Course.

SECURITY AND COMPUTER AWARENESS

Didactic objectives	Expected results
· To increase knowledge of IT tools and undesrtand their role in society.	· The student will have acquired the necessary skills and sensitivity to use IT system as tools created for the benefit and not to cause harm to others or to themselves.
· To avoid the risks associated with the unconscious use of video games and consoles (addiction).	· To recognize and avoid the risks associated with the non-responsible use of video games and consoles.

Figure 4 Summary of the security and computer awareness expected to be acquired at the end of the Intermediate Course.

3. ANALYSIS AND DISCUSSION

The didactic path ends with the administration of tests aimed at understanding the level of specific knowledge and critical ability developed by the students. For this reason, a different and specific test has been developed for each educational path. The test consists of 9 questions that contain the various disciplinary sectors introduced by Digital Education Lab [1]. Each topic is assigned a code to identify the area of specialization (INF, MAT, GEO etc.). The level of competence of each sector is measured through a numerical value that follows the sector code. Below is a list of the sectoral codes that characterize the intermediate course:

- INF/0: knowledge of basic technical informatic terminology.
- INF/1: ability to analyze simple problems and translate them to computer language (Make Code).
- INF/2: ability to analyze complex problems and translate them to computer language (Make Code).
- MAT/0: knowledge of basic technical mathematical terminology.
- MAT/1: ability to schematize and solve simple mathematical problems with paper or board support.
- MAT/2: ability to schematize and solve complex mathematical problems without any support.

- GEO/0: knowledge of basic technical geometric terminology.
- GEO/1: ability to analyze simple geometric shapes and to schematize them into fundamental parts.
- GEO/2: ability to analyze complex geometric shapes and conceive them as union of fundamental parts.

The first learning area relates to computer knowledge and terminology (INF/0). The first question relates to one of the most important concepts of programming: cycle syntax. Students are asked to answer, "*What is a cycle in programming language*?" There are four options, all designed to create confusion among children and evaluate critical ability.

Learning by Minecraft Education Edition shows that most students are able to detect small differences and recognize the correct answer. This is possible thanks to the structure of programming in Minecraft. The block language facilitates the understanding of the logical steps and the use of an ad hoc character, who executes the commands, allows you to view the consequences of each "code line". Therefore Figure 4 shows that 95.7% of the students answered correctly. It must be emphasized that even most students who made mistakes, were able to choose an almost correct answer and no one was completely wrong.

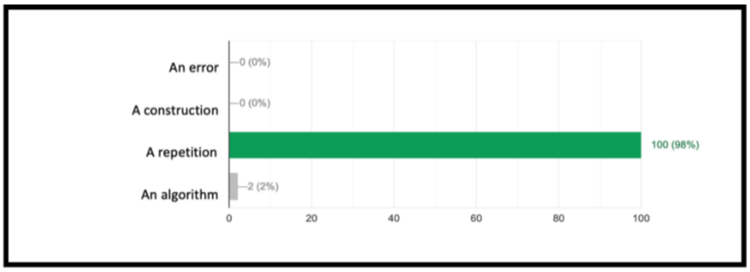

Figure 2 Score as a percentage of possible answers to the first question of the sector INF/0 "What is a cycle in programming language?"

The second question requires the understanding of what a graphic programming language is: "*What is Make Code?"*. Figure 2 shows that a very high percentage (61.4%) of students answered correctly; however, there is another peak related to the second answer, "A programming school", which resulted at 31.5%. The answer related to the fourth "An HTML language" (percentage 4,9%) highlights a reasoning by the students on the composition of the sentence, which leads them to choose, incorrectly, what is conceptually closest to the question posed.

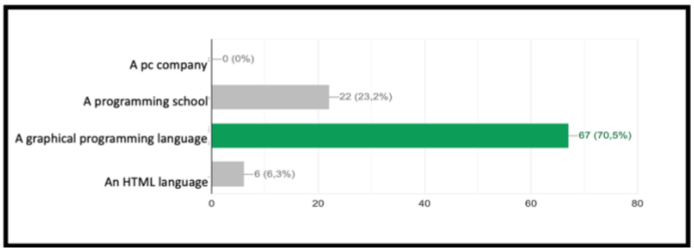

Figure 3 Score as a percentage of possible answers to the first question of the sector INF/0 "What is Make Code?".

The question "What is a function?" (sector INF / 1), the results of which are shown in Figure 4, once again underlines the ability to distinguish between very similar concepts by answering correctly (85.1%).

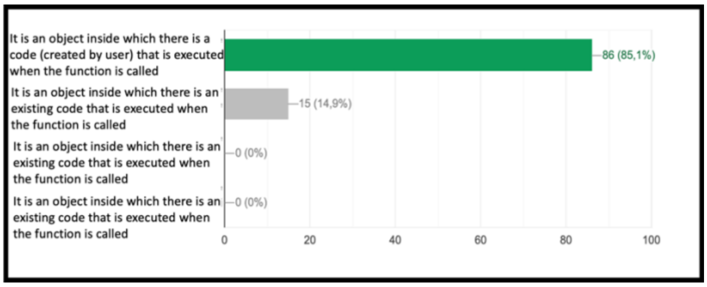

Figure 4 Score as a percentage of possible answers to the first question of the sector INF/1 "What is a function?".

The following questions are presented below with the percentage scores reported by the students. The questions in Figures 5-8 refer to precise Make Codes, developed specifically for this test. These codes fall into the fields of computer science and in some cases of mathematics and geometry. Looking at the answers, we see that in this case too, the students show great ability to reason in terms of code. It must be emphasized that they were not allowed to "execute" any code, but the answer had to be given by imagining the effect of the code.

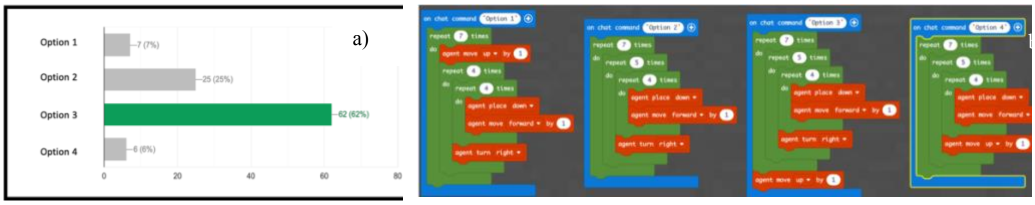

Figure 5 a) Score as a percentage of possible answers to the first question of the sector INF/2 "What code builds a house?" and b) the proposed codes.

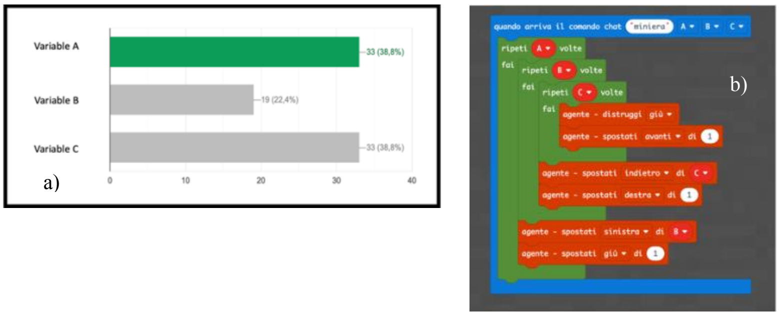

Figure 6 a) Score as a percentage of possible answers to the first question of the sector INF/2 "Which of the 3 variables do we need to increase in value to create a deeper mine?" and b) the proposed code.

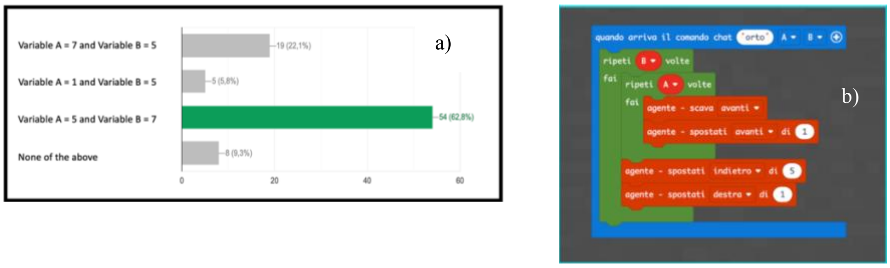

Figure 7 a) Score as a percentage of possible answers to the first question of the sectors INF/2 and MAT/1 "To create a 5x7 vegetable garden as in the photo. How should I set variables A and B? and b) the proposed code.

Figure 8 a) Score as a percentage of possible answers to the first question of the sectors INF/2 and MAT/1 "To create a 5x7 vegetable garden as in the photo. How should I set variables A and B? and b) the proposed code.

We focus on the last question, figure 12, to which most of the students answered incorrectly. Reading the answers, however, it can be observed that the most selected and the right answers are almost identical except for nuances. This tricked most of the students.

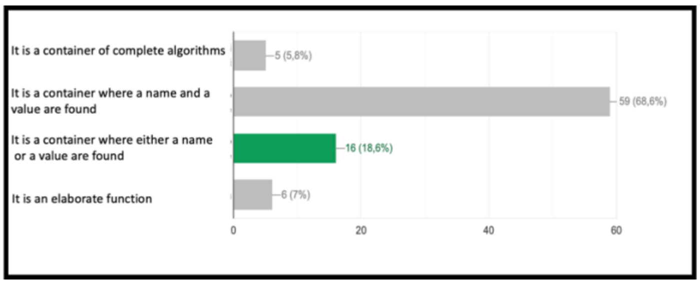

Figure 9 Score as a percentage of possible answers to the first question of the sectors INF/1 and MAT/1 "What is a variable?".

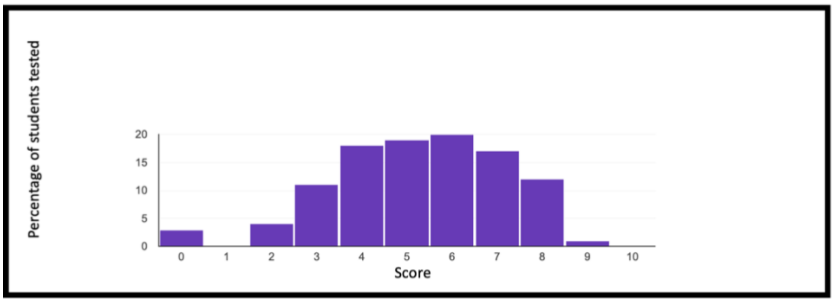

Figure 10 summarizes the overall score achieved by each student in the test. The points range from 0 to 9. The histogram presented is characterized by an average of 5.28 and a median of 5. The results obtained are very promising and underline that game learning guarantees fast and substantial learning even of complex concepts.

4. CONCLUSION

The inevitable transformation of our world towards the technological age cannot be overlooked in the educational sphere. The new digital tools, along with the appropriate didactic planning, can provide new teaching tools that are in some cases more effective on children's learning. In fact, the use of technology and game-learning helps to capture the attention of students, especially younger ones, favoring the focus on topics. Digital Education Lab has built educational programs based on the use of Minecraft Education Edition software. This work, which takes into consideration precisely the activity of the school, shows how the playful and social aspects accelerate the learning of even complex topics in the fields of computer science, mathematics and geometry. In particular, we have reported the results achieved by the intermediate course here. A previous article described in detail the didactic programs of the youngest students (Basic course). We believe that nowadays it is necessary to take advantage of the new means that our age makes available to us to improve the development of the skills and personalities of our children. Evolution calls for digital and education must keep up.

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Educational Robotics to Release Maths Anxiety. The Erasmus plus project Erasmus+ Key Action 203 – Strategic Partnerships Flipped Learning Practices to Release Maths Anxiety with the Use of Robotics

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ABSTRACT

Mathematics education is one of the keys to development in today's work life since we use math in every aspect of our lives in practical everyday activities and at work such as solving problems, managing personal finance, keeping things well ordered and using quantitative skills required by a great number of jobs. Primary school pre-service teachers play a crucial role to meet individuals' differentiating needs since the future will be shaped in their hands. Math anxiety is risk factor for some students for a comprehensive understanding of mathematics. As a result, our goal as educators should be to explore new tools to reduce math anxiety in teaching primary school mathematics. Among many alternatives, the flipped learning approach was chosen as a viable medium to reduce primary students' level of math anxiety with the use of robotics. The main goal of the Erasmus plus project Flipped Learning Practices to Release Maths Anxiety with the Use of Robotics is to enhance expertise of prospective teachers who are enrolled in primary teacher education programs. The project aims to help prospective teachers develop strategies in their work with students with high levels of math anxiety. Specifically, this two-year project plans to accomplish the following tasks: A modular curriculum designed with flipped learning including hands-on learning practices using robotics devices; A video library including explanations for the use of robotics in maths education in primary schools.

KEYWORDS

Cognitive neuroscience; cognitive development; educational psychology; mathematical ability, educational robotics.

1. INTRODUCTION

Math anxiety is a negative emotional reaction to math and numbers, feeding a vicious cycle of avoidance and ignorance.

For Sheila Tobias and Carol Weissbrod (1980) is "the panic, helplessness, paralysis, and mental disorganisation that arises among some people when they are required to solve a mathematical problem" and it is thought to affect a large proportion of the population". Sheila Tobias has been known for her research in the areas of math anxiety and math and science instruction.

For Ashcraft (2002), Math anxiety refers to "feelings of fear, tension, and apprehension that many people experience when engaging with Math". Math anxiety is thought to be "a trait-level anxiety and is distinguishable from both test anxiety (Kazelskis et al., 2000) and state anxiety (Hembree,1990).

Apart from aspects like gender, age and culture affecting mathematics anxiety, research has shown that emotional factors, such as general anxiety or self-esteem play an important role too (Orly Rubinsten and Tannock, 2010; Dowker et al., 2016).

Math anxiety is highly prevalent, affecting nearly 50% of grade-school children in the United States alone (Beilock and Willingham, 2014). According to the Organization for Economic Co-operation and Development

(OECD), 31% of 15-year-old students reported feeling nervous when solving a math problem and as many as 59% indicated that they were worried about math classes (OECD, 2013).

A math anxious student experiences math with more than a feeling of dislike or worry; it also affects physiological outcomes such as heart rate, neural activation, and cortisol (Faust, Ashcraft, 1996; Lyons & Beilock, 2012b). Notably, higher-math-anxious students show increased heart rates (Faust, Ashcraft, 1996) and, when cued with an upcoming math task, show neural activations similar to those found when individuals experience physical pain (Lyons & Beilock, 2012b).

Math anxiety has even been thought to operate similar to a phobia (Hembree, 1990; Pizzie & Kraemer, 2017), as brief exposure to math stimuli creates a behavioural disengagement bias similar to a fear-conditioned stimulus (Pizzie &Kraemer, 2017).

The conditions for math anxiety can be environmental (bad experiences, bad teachers), personal (lack of confidence, low self-esteem), dyscalculia, or cognitive deficits. Apart from aspects like gender, age and culture affecting mathematics anxiety, research has shown that emotional factors, such as general anxiety or self-esteem play an important role too (Orly Rubinsten and Tannock, 2010; Dowker et al., 2016).

But its precise developmental origins are still not known (Rubinsten & Tannock, 2010). Several causes probably come into play in this complex phenomenon that affects many millions of students worldwide.

It can often hinder the successful completion of tasks involving manipulation of numerical information and is a prominent cause of problem-solving difficulties across all age ranges (Ashcraft & Krause, 2007).

Because the detrimental impact of math anxiety on mathematical development is lifelong (Rubinsten & Tannock, 2010), it is important to understand its neurobiological origins, especially during the earliest stages of formal math learning in elementary school children (Menon, 2012).

Symptoms of maths anxiety include:

- Emotional symptoms: feeling of helplessness; lack of confidence; fear of getting things wrong.
- Physical symptoms: heart racing; irregular breathing; sweatiness; shakiness; biting nails; feeling of hollowness in stomach; nausea.
- Frustration from trying to do maths and not being successful.
- Not knowing where to start with questions or never getting the right answer.
- Confused and just wanting to quit and go home.
- Very stressed before and during exams.
- Begin to shut down and stop listening in class.

2. MATHS ANXIETY IN CHILDREN

Although the negative consequences of math anxiety are well understood, to date there have been few studies of interventions for remediating math anxiety in children.

According to Young, Wu and Menon (2012) this is in part due to the lack of a developmentally appropriate measure of math anxiety. To address this issue, these Authors recently “extended the Mathematics Anxiety Rating Scale (MARS), a standardized method for assessing math anxiety in older children and adults, to create the Scale for Early Mathematics Anxiety, SEMA.

SEMA has been shown to be a reliable and construct-valid with Cronbach’s $\alpha = .870$) measure of math anxiety in 7- to 9-year-old second and third graders (Wu, Amin, Barth, Malcarne, & Menon, 2012). Cronbach’s alpha (sometimes simply α coefficient) is a statistical indicator used in psychometric tests to measure their reliability, i.e. to verify the reproducibility over time, under the same conditions, of the results they provide. Generally, high reliability values are considered to be those ranging from 0.70 upwards.

Let's follow Young, Wu and Menon's study on children:

To examine the neurodevelopmental basis of math anxiety, we analysed functional brain-imaging data from forty-six 7- to 9-year-old children, which we obtained while the children determined whether addition and subtraction problems were correct (e.g., "2 + 5 = 7") or incorrect (e.g., "2 + 4 = 7"). In a separate session, we used the SEMA to assess math anxiety in each child. (..) We hypothesized that if children with high math anxiety view such stimuli negatively, they would show hyperactive amygdala response during math problem solving. Furthermore, amygdala connectivity with medial prefrontal cortex regions involved in emotion regulation would also be elevated when compared with such connectivity in children with low math anxiety. (..)

The study results were very interesting:

These results provide converging evidence for aberrant processing within local functional circuits in the amygdala of children with high math anxiety. Children with high math anxiety also showed reduced responses in cortical and subcortical areas that have been consistently associated with mathematical and numerical reasoning in children and adults. These differences were related to arithmetic complexity and were independent of sensory, motor, decision-making, or response-selection processes. Additional analysis using SEMA scores as a continuous variable confirmed the observed pattern of increased right basolateral amygdala responses and decreased frontoparietal activation with math anxiety. Furthermore, these effects occurred independently of individual differences in trait anxiety, working memory, and performance.

3. THE USE OF EDUCATIONAL ROBOTICS TO RELEASE MATHS ANXIETY

In terms of maths anxiety, several implications for education can be drawn. Maths anxiety seems to influence cognitive processing in a straightforward way - working memory resources are compromised whenever the anxiety is aroused. Given the pervasiveness of working-memory- dependent processing in arithmetic and math, this predicts serious effects of math anxiety (Ashcraft, Krause, 2007).

The very abstractness of mathematical symbols surely adds to the difficulties that people encounter when learning math, including difficulties in storing and using information in working memory. Acquiring the capacity for abstract thinking, of course, is a late developmental milestone.

Mathematics and computational thinking are very similar in many aspects. In both skills as abstraction, generalization, decomposition, algorithmic thinking and debugging are needed (Atmatzidou & Demetriadis, 2016). Robotics by introducing computational thinking gives the possibility to improve students' skills to systematically process tasks and develop the sequenced step by step coding commands (Chalmers, 2018), furthermore littlest students can improve their fine motor skills while building robots such as Lego WeDo.

Robotics is a wonderful way to introduce students to computational thinking considering that students of different ages and genders can learn and gain the same level of computational thinking, however different teaching and learning methods may be needed (Daniela, 2019). Of course, programming is a huge part of robotics as well as mathematics and it may look complicated, however nowadays there are a lot of graphic programming possibilities, for instance, Lego WeDo interface, that make it possible to make robots and program them even for the littlest students. Moreover, it gives the possibility to focus on developing students' computational thinking skills (Daniela, 2019) as well as improve their mathematical skills and/or show them how their skills can be used elsewhere.

4. CONCLUSION

The finding of many of the studies cited is that maths anxiety can be detrimental to learning in general and its effects can even be compared to those of a phobia.

At the same time, several case studies show possibilities for remediation to maths anxiety.

Important steps are:

- early screening of everyone child to identify any issues like dyslexia and dyscalculia before negative experiences create self-confidence issues;
- kindergarten and primary school teaching of math applying modern ideas of active learning and appropriate context;
- integrate technology immediately and eliminate the teaching habit like times tables;
- use educational devices and robots to introduce children to computational thinking and support the development of their logical competences.

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EMERGING TECHNOLOGIES

A look to the future through emerging technologies that interact with the educational environment such as AI, Blockchain, etc..

The impacts of extracurricular activities for implementing STEM Approach and teaching Artificial Intelligence in K12 Education at Polo Educacional Sesc in Rio de Janeiroc

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ABSTRACT

This work presents the implementation of activities carried out to promote STEM Education at Polo Educacional Sesc1, an educational institution in Rio de Janeiro that offers free and quality education to young people from all Brazilian states.

The article presents the implementation of an educational initiative called STEM + AI Club, through the Mathematics discipline and the Educational Technologies team, aimed at enhancing the integration between student and school and expanding the discussion of transversal themes through extracurricular actions.

The work points out that through this initiative, students assume autonomy in their learning process and reach significant maturity in projects where they take part as protagonists of their educational process.

KEYWORDS

Extracurricular Activities, STEM, Artificial Intelligence

1. INTRODUCTION

The school has faced the mission of providing students with a teaching and learning environment that dialogues with the world around them. Currently, the generation of students in the classroom is made up of digital natives, they were born in the era of connectivity and most of them have information, in real time, in the palm of their hands, through their mobile devices. In fact, knowledge has never traveled so quickly and has never been so accessible. Technology is advancing, becoming more and more popular, and education is committed to keeping up with these changes.

Therefore, educational institutions, especially the K12 education schools, need to be aligned with the changes that society has gone through. Thus, keeping up with technological and industrial advances are important indicators of the way forward. We live in a time in which process automation, the internet of things (IoT) and artificial intelligence are realities that have impacted citizens' daily lives, and understanding these changes is fundamental for the formation of citizens in the 21st century. Therefore, the integration of the school, with the reality in which it is inserted, makes education active and meaningful for students.

In this sense, an extracurricular approach to meet this need was implemented in the Mathematics course at Polo Educacional Sesc, a pedagogical action called STEM + AI Club. The Club is an initiative carried out horizontally by students and educators and aims to expand the investigation of themes that are part of the scope of Mathematics within a multidisciplinary approach. Mathematical concepts act as a common thread in experiments, through the inclusion of practical activities that encourage the development of technical skills, and in debates involving science, technology, engineering and design.

In 2020, the project was developed in partnership with the institution's Educational Technologies team which, through resources such as videoconferencing platforms like Google Meet, StreamYard and Streamings such as YouTube and Facebook, in addition to the resource for collaborative programming Google Colab, allowed the project to be successfully implemented, contemplating the students, educators and the general public.

Thus, this work seeks to contribute to the issue that deals with innovative teaching modalities, presenting a project developed with high school students. This work is organized as follows: in section 2 we present the theoretical foundation of this project, in section 3 the methodological discussion, in section 4 the implementation of the project, in section 5 some results and, finally, section 6 presents conclusions and final considerations.

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2. THEORETICAL FOUNDATION

Papert (1997) states that the teacher's role is to provide the conditions for the invention, instead of providing already consolidated knowledge. The difference between creating and reproducing is very evident when an educational activity is proposed in a creation space. The emphasis on stimulating creativity and on the search for innovative solutions is a counterpoint to exercises with standardized answers, in which students reproduce something they memorized during an expository class.

Hands-on activities, mediated by digital fabrication technologies, have the potential to help the learner to achieve the goals for discovery learning through STEM projects (Halverson & Sheridan, 2014). STEM is the acronym for Science, Technology, Engineering and Mathematics. This approach allows the student to take the lead in their learning and develop important skills for the 21st century professional (Croak, 2018).

Likewise, Artificial Intelligence (AI) is an increasingly ubiquitous technology in society. AI is a field of Computer Science and Computer Engineering that is interested in the study and creation of systems that can exhibit intelligent behavior, perform complex tasks such as reasoning, planning, problem solving and decision taking. Leading AI researchers and publications define this area of knowledge as the study and design of intelligent agents, in which an intelligent agent is a system that perceives its environment and performs actions that maximize its chances of success (Gadanidis, 2017).

These themes were chosen to be part of the club's program for two reasons. The first points to the need to debate the impacts of new technologies on society from two perspectives, that of those who use the technology and that of those who develop it. Students realized that this integration is an important way to understand how new technologies have changed our daily lives. The second reason was that the updating of the Brazilian high school syllabus guidelines included the teaching of robotics, programming, automation and AI to be addressed by the Mathematics discipline.

Thus, this work presents an initiative that provides a learning environment through discovery, enhanced by collaborative, face-to-face and virtual spaces of exploration. Discovery learning assumes that students who discover scientific concepts for themselves create deeper and more meaningful knowledge structures that are easier to transfer to new contexts (Bransford & Schwartz, 1999).

In this same sense, it is important to consider that by proposing a disruptive teaching and learning environment, for the student who for years had their educational experience based on the traditional model, we make them stop playing the passive role of receiving knowledge, and become co-responsible for the construction of knowledge (Machado, Câmara & Willians, 2018). For this reason, in this new context, it is important that the appropriate learning environment is provided to the student, making it clear to them the objectives of each proposal to be carried out (Schneider & Blikstein, 2015), thus making the work be developed in a safe emotional environment where teamwork, collaboration, knowledge exchange and collaborative learning are encouraged.

3. METHODOLOGY: EXTRACURRICULAR ACTIVITIES IN HIGH SCHOOL

Collaborative and hands-on activities are important resources for meaningful learning. These actions can be implemented through extracurricular initiatives, without impacting the organization of the regular syllabus.

One way to provide these activities is the Interest Clubs. At the Polo Educacional Sesc, students and educators, who have common interests, organize the club horizontally. The aim of the project is to deepening discussions on issues related to real and current problems, promoting an interdisciplinary integration.

3.1. The importance of teaching Artificial Intelligence in K12 Education.

AI has been applied in actions ranging from Marketing, Medicine, Engineering, Politics, services related to Human, Financial Resources, and even leisure activities, including Games and Social Networks. Smart devices are found in numerous technological resources and young people are users of most of them.

The ubiquitous nature of this technology has caused people to interact with AI passively without considering, for example, that this interaction exposes their individuality and privacy.

One of the ways to raise awareness and enlighten the population about this technology is through Literacy actions in AI, so that users interact with devices equipped with this resource in a critical and less passive way. The best place for these actions to take place is in K12 Education-

3.2. STEM + AI Club

The STEM approach allows the student to take the lead in their learning and develop important skills for the 21st century professional. Likewise, AI is a technology that is part of our daily lives, and that has expanded its field of acting in a short period.

These themes were chosen to be part of the Mathematics Club with the aim of making students realize that Math is in everything and is a field of study integrated in different areas of knowledge. In the first two years of operation (2019/2020), this club addressed issues related to AI, its implementation and impacts on society. In 2021 the club expanded its experiments and debates to the STEM approach.

4. PROJECT REALIZATION

Next, we will report on the club's implementation process.

4.1. The first year of the Artificial Intelligence Club – 2019: The construction of the FRANKIE robotic device and the holding of face-to-face workshops.

In the first year of the Club, students participated in workshops that promoted the introduction of Machine Learning concepts through Educational Robotics.

The FRANKIE robot, an acronym for Fostering Reasoning And Nurturing Knowledge through Informatics in Education, was prototyped at the school Maker Space. This robot makes it possible to teach students the mechanisms behind an artificial neural network, promoting the learning of what makes an AI resource so important in countless applications.

During the workshops, the students "taught" the robot geometric shapes that, upon recognizing them, should make a decision in the environment. Realizing that the robot's AI algorithm sometimes did not adequately recognize the learned image, and consequently moved in a different direction than expected, the students compared it to an autonomous car and raised the following question: "Whose responsibility would it be if an AI, who drives an autonomous car, makes an inappropriate decision and causes an accident? From the owner of the car or whoever developed the AI algorithm?".

The first year of the AI Club showed that the theme goes beyond learning math and computer science concepts. The meetings with students pointed to the need for a multidisciplinary discussion, which guided the club's actions in 2020.

4.2. The second year of the Artificial Intelligence Club – 2020: The set of remote actions involving experimentation and debates

With the pandemic in 2020, the Club maintained its activities with remote experiments and live broadcasts to debate some questions about AI.

Machine Learning trials were introduced using free web interaction platforms such as Teachable Machine and QuickDraw and converged on hands-on programming activities using the Google Colab platform, which allowed students to collaboratively program using Learning Libraries from Machine in Python language.

One of the workshops, organized by members of the Club, provided experimentation with an AI algorithm. This experiment was open to the public and disclosed on the school's Social Networks (https://bit.ly/instagram_disclose) and carried out through a video call on Google Meet and had the purpose of presenting the functioning of the WiSARD Weightless Neural Network (RNSP) based on machine learning, in which the AI can recognize images of pigs and dogs and differentiate them. The RNSP WiSARD is a neural network that has a supervised training characteristic, that is, it is necessary to inform which class a certain training pattern belongs to (Machado, 2017).

On the other hand, the debates promoted by the organization of the AI Club, in the form of Livestreaming, were attended by educators and professionals from different areas of knowledge. We highlight the debate: “Power and Politics in the Digital Age”. In this live broadcast, it was discussed, among other topics, how AI is used in the dissemination of Fake News and targeted political propaganda. During the meeting, the young people detailed the emblematic case of how the extinct British company Cambridge Analytica managed, through permissions given by users in terms of using quizzes on Facebook, to have access to all their likes and the likes from their network of friends.

The actions involving experiments and debates proved to be complementary, as the students dealt with the topic from the perspective of those who were closer to technology, who had experience with it. The virtual actions performed can be seen in the following playlist: bit.ly/bit.ly/playlist_club_ai_2020.

4.3. Expansion of the proposal in 2021: STEM + AI Club

In 2021, the club expanded its actions to the STEM approach. This approach was implemented, inspired by the reforms implemented in Brazilian education in recent years.

Just as the Brazilian Ministry of Education proposed actions to modernize and update secondary education through the the Common National Curriculum Base (CNCB – BNCC in Portuguese)[12], the STEM approach is a government initiative, which emerged in the United States, with the objective of improving the learning of exact sciences. Currently, the organization of the Club has 15 young people, who jointly develop proposals for the Club. The virtual actions performed in 2021 can be seen in the following playlist: bit.ly/playlist_club_ai_2021.

In the second semester of this year, the club resumed its in-person actions with students, due to the return to classes at school. Students are working on projects related to the following features: Arduino Platform, Raspberry Pi Minicomputer, Lego Mindstorm, and Gogo Board.

5. RESULTS

In this section, we will address some results obtained by this Club, and we will also carry out some reflections on the impact of their implementation.

We will highlight in this discussion the year 2020, when the initiatives were carried out exclusively in a virtual way, contemplating students and participants from all over Brazil. These actions were organized by our students and were made available on social networks, both on the institution's YouTube channel and Facebook. There were more than 4700 views and 861 hours of watched content, with participants from c states in the country.

[12] BNCC. Base Nacional Comum Curricular. Brasil. http://basenacionalcomum.mec.gov.br/ (ver. 21.09.2022).

We have compiled below some interactions that social media viewers had with club members.

" - Great discussion! I am reflecting about some points made! Congratulations to you all!"

" - I was more excited to work on this theme at the Science Fair."

" - Good evening! I am impressed with the talent of these young people! Excellent approach, much needed for the moment!"

" - Congratulations guys for the initiative, I'm a former student, I'm studying AI now and happy to see how far ahead the school is."

" - I am a Public Education teacher and I am grateful for this opportunity!"

" - Students should have incentives to continue creating, as they are capable and only need motivation. And AI will redeem it."

" - This live broadcast revolutionizes our thinking about some knowledge we thought we had."

These interactions, carried out through live broadcasts and discussions through chat, boosted the interest of young people who are part of the club organization, leading them to participate in other initiatives that deal with the themes.

In 2020, for example, some students from the STEM + AI Club participated in the challenge of the Brazilian Ministry of Science, Technology and Innovation (MCTI in portuguese), entitled Satellites and AI, achieving the expressive third place in the category of secondary and technical education. In 2021 we also have students participating in the AI Olympiad organized by Celeritas with support from the MCTI, demonstrating how this initiative promotes student interest in issues related to real-world problems.

6. CONCLUSION AND FINAL CONSIDERATIONS

The promotion of disruptive actions at school can happen through initiatives that consider preparing the student for a constantly changing society, carrying out activities that provide the creation of learning environments that break the formal structure of the classroom, making the world around the student a school.

The study presented in this article shows a proposal to implement a virtual extracurricular activity, mediated by Educational Technologies, which approaches mathematics through a collaborative and hands-on methodology, called STEM + AI Club.

We conclude that the club is an initiative that place students at the center of their learning, allowing them to take part in the actions carried out, so that they can actively contribute to the choice of what they want to learn. The teacher, as a mediator, works horizontally with the students, and plays the role of guiding the actions.

To illustrate the impact of this action on the institution, the testimony of one of our students is available at the link below bit.ly/student_club.

The results of the interactions show that this extracurricular activity model has been effective, promoting the engagement of both the young people at Polo Educacional Sesc and the external public who interact with the club's actions through shared actions on social networks.

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Cooperative learning through a S.T.E.A.M. lab about the studying of San Marco restoration.

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ABSTRACT

The essay narrates the didactic experience carried out at the Pietro Palumbo First Grade Secondary School during an activity promoted by the M.I.U.R. within the "Piano Nazionale Scuola Digitale" [National Digital School Plan] called "Premio Scuola Digitale" [Digital School Award]. Using the "Jigsaw" methodology, the teachers designed a teaching unit on the theme of restoration of St. Mark's bell tower in Venice, which enabled the pupils to deal with a theoretical theme through the STEAM (Science, Technology, Engineering, Art, Mathematics) philosophy, which combines skills and teaching subjects to simulate real working life.

KEYWORDS

Venice Bell Tower; Jigsaw; flipped classroom; 3D print; CAD; polyhedron; Sheet; axonometry; Restoration.

1. DESCRIPTION

1.1. Description of setting

The proposed didactic activity was carried out at the Pietro Palumbo First Grade Secondary School in Villabate, involving the pupils of the IIIi in the school year 2020-2021. The class is made up of nineteen pupils aged between thirteen and fourteen, of which thirteen are female and six are male.

1.2. Description of the educational experience

When I started my activity as a technology teacher, the methodology used followed a precise pattern, the same one inherited from my teachers and applied to the teaching experience carried out at the Faculty of Architecture in Agrigento. This scheme foresees the use of the blackboard as the main means of didactic mediation; the pupils would have had to copy what I wrote and, later at home, rework this information integrating it with the notions present in their textbooks. But I soon realized that most of my pupils were not really learning and that only a small part of them were able to develop an effective study methodology. The next step was to reorganize the lessons on the basis of a guiding scheme that would show them the logical procedure to be implemented in a specific situation for the resolution of a problem posed. On the surface, the situation seemed visibly better, the pupils showed more security and tackled the proposed activities with greater commitment. But the moment a similar but slightly different alternative activity was proposed, the pupils were unable to adapt the procedure acquired with the guiding algorithm to the new specific task, constantly waiting for suggestions from the teacher and in the most extreme cases for me to do the work for them. An excellent opportunity to change the approach to the way of teaching was offered in 2021 by an activity promoted by M.I.U.R. as part of the "National Digital School Plan" called the "Digital School Award".

I worked, in agreement with the Headmaster[13], with other teachers of my class council to develop a path that had different solution strategies, requiring cooperation between pupils for the resolution of a problem extrapolated from a real context but above all that would increase in them a critical conscience and a new spirit of investigation that helps them to observe the reality around them. In addition to technology, the teachers

[13] The Headmaster of the Secondary School Pietro Palumbo is Dr. Mario Veca, co-author of the essay.

involved were those of literature and mathematics[14], who, in synergy, developed a multidisciplinary learning unit based on the study of St Mark's bell tower in Venice and the events of its restoration following its collapse in 1902. The topic was addressed through the study of historical sources and with the use of information technologies supplied to the school; an approach that integrated multidisciplinary teaching with active knowledge-building techniques adapted to the resolution of a complex problem taken from a real context. The planned path was divided into five main phases, each of which divided into other minor activities:

Phase 1[15]: The teachers, through a participatory lesson held in the classroom, framed the topic to be addressed, analyzing each single phase and presenting the authentic task that the pupils faced at the end of the teaching unit. They also divided the class into four homegroups, applying the “Jigsaw”[16] methodology, so that the members of each group have different specificities. During this phase the teachers also provided a historical background on the first decade of the twentieth century in Europe, specifically addressing the theme of the collapse, the design hypotheses for its reconstruction, while defining the concept of historical identity and artistic authenticity.

Phase 2[17]: The teachers created a virtual classroom through the “Google Classroom” application in which they entered the teaching materials, useful in the different phases of the work. The pupils, in “flipped classroom” mode (Maglioni & Biscaro, 2014), studied the proposed texts, viewed short documentaries and lessons in asynchronous mode and finally analyzed the period photographs found by the teachers. The “Edpuzze” web-app was used in particular for the videos, which allowed teachers to insert notes and interactive questions while playing the videos. To proceed with the viewing of the video, the pupil had to respond to these places, this system made it possible to have a precise report of the activities carried out at home by the pupils in order to have planned the classroom activities in a more punctual and targeted way.

Phase 3[18]: In this phase the teachers carried out the preparatory activities for the realization of the final project, organizing the timetable to ensure their co-presence. A participatory lesson addressed the issue of the birth of restoration in Europe starting from the two opposite interpretations provided in England by John Ruskin and in France by Viollet Le Duc. The analysis of the case study allowed to focus attention on the Italian events and on the new vision of historical restoration, highlighting the Italian debate and the socio-cultural implications linked to the desire for a new reconstruction. Each home group, after a careful survey on the web, created a synthesis multimedia product, through the “Google sheets” application, which provided each group with a clear picture of the different visions on the restoration of historical monuments. Parallel to the analysis of the historical and artistic framework, the theme of solid geometry was introduced through the analysis of the environment that surrounds them, in search of the flat and three-dimensional geometric shapes that make up the shapes around us. The concepts of base surface, base perimeter, height of a solid, lateral surface, total

[14] The teachers involved were: Caterina La Russa, teacher of mathematics and science, Maria Lo Cicero, teacher of literature, Giuseppe Tantillo, teacher of technology and co-author of this essay.

[15] The first phase, which lasted 2 hours, was carried out mainly in the classroom with the simultaneous presence of the three teachers.

[16] The jigsaw is a specific technique of cooperative learning, formulated by E. Aronson in 1978 which, similar to a puzzle whose overall image is given by the contribution of every single piece that composes it, every part of the work attributed to a student it is essential for the full understanding and completion of the final product. The students belonging to the class were divided into 4 groups, called home, each in turn made up of 4 pupils. In addition to the homegroups, 4 expert groups have been formed, each of which has a member of each homegroup within it. Each expert group will carry out part of the work assigned by the teacher, relating the results of the work to the home group to which they belong. Each home group will be able to complete the assigned work only if each member has done the work in the expert group correctly, cooperating actively in the group. The methodology is strongly structured to the point that the quality of the final product depends on listening attentively to the other people in the group. See Banzano, M. and Minello, R. 2002. Learning together: a workshop on didactics of cooperative learning, Armando Editore, Rome.

[17] The second phase was mainly carried out at home in flipped classroom mode through the cloud suite made available by Google. The estimated duration of this activity, which varies from pupil to pupil, is about 3 hours.

[18] The third phase, which lasted 12 hours, was carried out in different school environments: in the classroom, in the scientific-technological laboratory and in the computer laboratory. 2014). *La classe capovolta.* For each of these shapes, the pupils prepared graphic tables, each containing: an isometric axonometric view, a cavalier axonometric view, the cardboard development of the polyhedron and a form containing the geometric formulas for each primitive needed to solve the problems in Google sheets.

surface, volume and specific weight have been defined. This knowledge has been applied in the analysis of the bell tower in search of the main geometric shapes that have been reworked in some graphic tables produced with the method of axonometric, isometric and cavalier perspective[19] [8]. These tables provided support for the next stage, during which the pupils, divided into "expert" groups, solved solid geometry problems using the "Google Sheets" application, from which it was possible to obtain the measurements needed to reconstruct a model of this bell tower in vector graphics. In fact, after having dealt with the topic of block coding, and having practiced with the graphical interface of the "Autodesk Thinkercad" application, the pupils, in small groups, redesigned the polyhedra previously represented with traditional methodologies in the graphical environment of the application. At first they experimented with the creation of solids with the standard interface, which involves the creation of drawings using the touch screen of the tablet made available to them, and later through the "code-block" interface, they learned how to create solids, perform mathematical, geometric and logical operations through blocks of code that follow the same principles implemented in more popular platforms such as "Scratch 3.0".

Phase 4[20]: A “Lincoln” style debate was organized in the classroom, a variant of the discussion useful for making pupils acquire skills in the field of logic. The class was divided into two large antagonist groups who faced each other on the theme underlying the learning unit. If there is a collapse of an important historical-artistic monument, what should be the correct way to intervene: reconstruct the image of the monument or preserve the remains as historical documentation? One group supported the reconstruction hypothesis while the other tried to highlight the importance of preserving the authenticity of a work. After having elected one of their representatives, the groups began to confront each other on the basis of the questions that a moderator, in this case the Italian teacher, asked them. The results of the debate were summarized in a video documentary in which the two representatives of the group presented their ideas[21].

Phase 5[22]: After reconstituting the "home" groups, the pupils belonging to each group built a three-dimensional model of the bell tower with "Thinkercad" through the data obtained from the resolution of the problems carried out in phase 3 by the individual components involved in the groups "expert". Each group, after downloading the file in their own "Google Drive" area, reworked the file previously drawn through the Cura application, in order to make it compatible with the 3d printer supplied to the school. After processing the data, each group moved the file to a special USB key, and in shifts, to avoid gatherings in the scientific-technological laboratory, they loaded the plastic filament, calibrated the base of the printer and produced the model of the bell tower.

2. CONCLUSION

2.1. Results

The proposed experience was aimed at promoting greater awareness of the learning experience in the pupil by shifting the focus from the proposed contents to the way in which they were constructed, through a positive interdependence with the other members of the group. The whole activity is centered on the concept of responsibility, each pupil has taken charge of the success of their group, overcoming the problems related to the acceptance and tolerance of others and, at the same time, increasing personal self-esteem. No less important is the concept of sharing not only understood between pupils but above all between pupils and teachers who, while respecting their roles, have a common goal to pursue.

The role of the teacher is recognizable in the preparation of the case study on which to engage the groups, through the search for the material to be used in carrying out the activities, through the management of the different steps that will lead to the performance of the reality task, but above all as a support to the functioning

[19] The primitive forms discretized by the volume of the bell tower of San Marco in Venice were: parallelepiped, pyramid and cylinder. For each of these shapes, the pupils prepared graphic tables, each containing: an isometric axonometric view, a cavalier axonometric view, the cardboard development of the polyhedron and a form containing the geometric formulas for each primitive needed to solve the problems in Google sheets.

[20] The fourth phase, which lasted one hour, was carried out in the classroom by changing the classroom setting. The desks were arranged in such a way as to divide the room into two symmetrically opposed parts.

[21] https://drive.google.com/file/d/1jv4joE20i67mzvdN4T1TSCjr4YNtSDhO/view?usp=sharing (ver. 21.09.2022).

[22] The fifth phase lasted 3 hours and took place mainly in the science and technology laboratory.

of groups. In fact, even in an external position, the teacher has the task of making preliminary decisions, in the formation of groups, and extemporaneous in itinere, to avoid the emergence of conflicts between the various components or to avoid the frustration of the best students who are entrusted with the task of towing the remaining components.

Among the problems that emerged there is certainly the time required to carry out the activity, which was often not compatible with that of traditional teaching combined with the timetables of the teachers who were often unable to guarantee the hours of co-presence at school. Another problematic element is constituted by the ability of the groups to immerse themselves in the proposed experience which often limits their commitment. Where possible, in fact, it is necessary to share the case study with the students, making them participants in the choices, proposing different alternatives. Finally, another problem that emerged during the performance of the activity was that of making sure that all members of the group possess certain prerequisites in terms of social skills necessary for carrying out all collaborative activities.

2.2. Broader Value

The experience carried out at the Pietro Palumbo school provided interesting insights to the whole educational community of the institute as the pupils learned abstract concepts through an experimental approach that identified them as active subjects in the learning process. Through the STEAM methodology, to learn by doing, it was possible to enhance the pupils in the educational process by making them protagonists and bringing out an often underestimated potential in them. The structuring of the activity has also enhanced the specificities of each pupil, offering the possibility of a continuous comparison that has had a direct impact on social skills, offering a different vision of the error, not an indelible stain in their work, but a stimulus to overcome one's limits by learning from the mistakes made.

Figure 1: The students during the different phases of the activity .

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Would you please call me Marco Tullio?": Cicero, a chatbot from the past

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ABSTRACT

The paper shortly describes the design and implementation of a chatbot by a group of fourth-year students of the Armando Diaz High school in Caserta (age: 16 years old). This report resumes the methodology adopted to create a good quality chatbot representing the Latin orator Cicero (the project's final output). The application of Artificial Intelligence (AI), normally associated with STEM subjects, in this case has given productive and stimulating results (in terms of learning and contents' acquisition) in a not scientific subject such as Latin.

KEYWORDS

"Chatbot"; "Artificial Intelligence"; "AI driven learning"; "Latin"; "Computational thinking"; "Machine Learning"; "Computational Linguistic".

1. DESCRIPTION

1.1. The setting

In October 2021, I decided to take part in Europe Code Week (October 9-24 2021)[23] with my 27 students (age 17 years) from the fourth year of high school (Liceo Scientifico) Armando Diaz in Caserta, in order to give them the opportunity to experience computational thinking and Artificial Intelligence within a subject that is normally not associated with ICT and digital skills: Latin.

The classical Latin syllabus for the fourth year includes an in-depth study of the works of Cicero, an author introduced in the third year's Latin curriculum: this prior knowledge has facilitated the project's implementation because the students already possessed a range of information about Cicero, a basic prerequisite for the creation of the chatbot.

The tool used for the completion of the task was Landbot.io[24]: this platform was chosen for three main reasons.

The first is that the free basic version of Landbot.io allowed the project to be completed without upgrading to the paid version. The full version's trial lasts for five days, but once the chatbot has been created, it is possible to keep working on it before deciding to publish the final output, and all without switching to the paid version.

Secondly, Landbot.io has a very intuitive drag and drop interface, that does not require a single line of code from the user, which was an added value seeing that just few of my students had practiced coding before this experience.

Finally, Landbot.io is an application that allows the bots to be published in many different formats including landing pages, website integration, pop-ups and on multiple mobile channels such as Facebook Messenger and WhatsApp, so students may share their work with other users (friends, peer groups, community members): I liked this social aspect of the tool's application that facilitates the dissemination of the project, as well.

[23]The Europe Code week is a week organized by EU to celebrate coding in Europe, encouraging students to learn more about coding. See information about at: https://codeweek.eu/
[24] https://landbot.io/

In addition, Landbot.io provides a series of templates to not start from scratch, a sort of scaffolding that makes it easier to design a chatbot also to beginners with no mastery of computational thinking.

1.2. The educational experience

The project was focused on the creation of a chatbot impersonating the ancient Latin orator Cicero, able to speak both Italian and his own language.

The main objectives of this learning path were:

- to enhance my students' understanding of the great potential of communication managed by Artificial Intelligence;
- to boost two fundamental skills indicated in the DigComp 2.1 Framework [1]: 1.1 the ability to search and select information on the web (in this case about Cicero) 1.3 the ability to develop digital content.

The method was based on the development and use of strategies that would allow the students to proceed autonomously in the realization of the chatbot once I had shown them the stages of chatbot's programming.

The students were divided into groups and within each group the members had different roles assigned: collecting information on the web, preparing the plots of the chatbot conversations, transferring the information on the platform caring the technical aspect, disseminating the final output on social canals.

As a consequence, several chatbots were created from this project:

- the chatbot Cicero as expert in philosophy and author of treatises such as "De Amicitia" or "De finibus bonorum et malorum", who gives advice on social relationships and life in general according to his expertise in the field;
- the chatbot Cicero as author of the Epistolary, who tells about the events of his life extrapolated from letters to users who are curious to investigate the secrets of his biography;
- the chatbot Cicero as the amazing orator, who illustrates his powerful speeches given in tribunals and forum as examples of public speaking.

To facilitate the use of Landbot.io I have created a tutorial for explaining the main tool's features and commands.

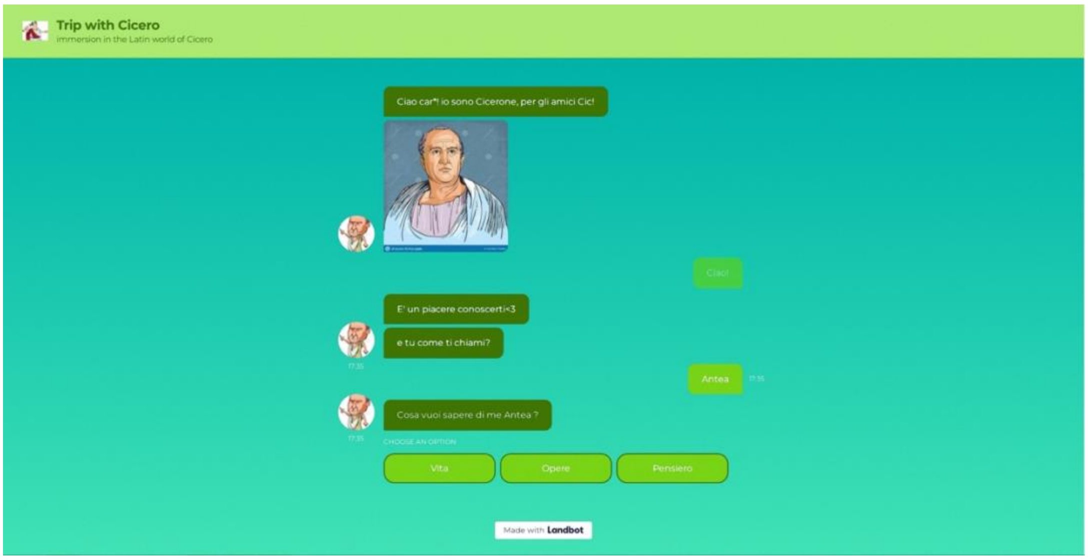

Fig. 1: Example of Cicero chatbot

2. CONCLUSION

2.1. Results

The students have been collaborative and enthusiastic during the whole project.

They were initially afraid of failing the task, thinking that they would not succeed in accomplishing it because they had never designed a chatbot before nor had any experience in computational thinking applied to school subjects, but they appreciated the originality of the assignment since the very first moment: the AI’s mediated approach to Latin was something unusual for them, and this novelty activated and stimulated their brains.

As they progressed in the experience, they revealed very good cooperative learning skills in both theoretical and practical aspects of the project.

At the end of the learning path, the students certainly improved their ability to work in teams expressing their creativity, but the most important result is that they changed their attitude towards Latin, a subject that is unfairly regarded as not matching with digital technology.

With the chatbot Cicero I introduced in my classroom a good practice to replicate in the future: on regular basis we will dedicate some hours each month to “learning pills” of digital Latin (or “Latin for nerds” as I have nicknamed it), in order to demonstrate that Latin does not smell of mold nor taste of old but can be irresistibly geeky.

With this project the students leveraged technology to take an active role in choosing resources on the web and to construct knowledge, they achieved the contents’ settled goals, and demonstrated competency in their learning objectives. They made a meaningful learning experience and I tested their satisfaction with a Google questionnaire: the feedback was encouraging, they rated the whole experience as “involving” and “interesting” and appreciated the innovative approach to Latin that usually is seen as an obsolete subject, very distant from the reality around them and “useless”.

As a teacher, through this project I had the confirmation that the use of Artificial Intelligence in school and the application of chatbots in the classroom, actually allows us to adopt new teaching techniques and new student-centered strategies to meet the needs of learners as individuals and not only as members of a class group.

In addition, I realized that implementing AI in school settings can give a strong contribution to the formative success of distance learning activities and can bring enormous advantages in terms of rationalization of educational resources and quality of teaching/learning procedures.

Also in terms of learning the subject’s contents, the project has produced positive results: students have deepened their knowledge of Latin language and culture, in full compliance with the ministerial disciplinary programs.

The impact on the community was positive because the project was included in the Europe code week and then acted as a driving force and promotion for the digital initiatives of the Institute by ensuring that it did not remain confined to our school but was disseminated and sharedwith other teachers and students.

To have a sample of the chatbots realized, you can see the two Ciceros created by my students Grazia Aspromonte[25] and Dennis Marotta[26] from 4 I Liceo Scientifico Armando Diaz, the class involved in the project.

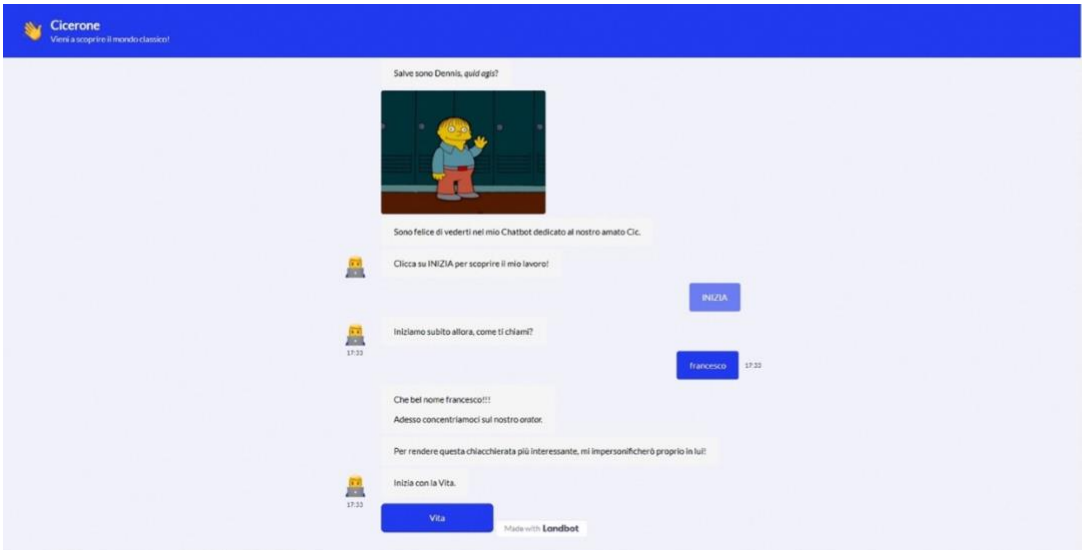

Fig.2: Another example of Cicero cahtbot.

2.2. Broader value of the experience

From this experience can be learned that the application of AI in the classroom can be adopted across the whole curriculum in various subjects and in a cross-curricular perspective: it would be just as effective in second language (L2) learning, where the conversational agent can act as a tool to test lexical knowledge with increasing complexity.

Distance learning has imposed, also for not STEM subjects such as Latin or English as a Second Language, a reconceptualization of the disciplinary contents mediated by digital tools, and this project is an attempt to present traditional topics in completely new contexts that are also close to the labor market.

I wanted to demonstrate to my students, but especially to myself, that it is possible to design a chatbot even without having complex knowledge of computational thinking, and that Artificial Intelligence is not an enemy of traditional learning, but an ally because if it is true that there will never be a chatbot (even though it's called

[25] https://chats.landbot.io/v3/H-1055161-SSRCK13X6L6MM6G6/index.html
[26] https://chats.landbot.io/v3/H-1034592-S5FM0UA9FEI515CV/index.html

Cicero) that can usurp the teacher's valuable role as educator, however having one as an accomplice in supporting students’ learning, is still a resource for teachers.

2.3. Relevance to Theme

Artificial Intelligence (AI) and laboratory approach can be powerful tools also in not STEM subjects such as Latin, since they allow to develop the skills and competences that usually are fostered in scientific education’s settings.

The reflection on the revision of Latin’s didactic methods is aimed at integrating this subject with other disciplinary fields.

The Latin lectures in Italian school are mostly based on a very traditional, teacher centred approach which seldom gives digital technologies the deserved space and attention for deep, systematized and active treatment of the subject.

However, this experience’s narration identifies an exemplary learning path that indicates how implement and embed effective and relevant scientifically contents into the Latin curriculum, finding innovative solutions for a reorganization of classical languages’ teaching and learning.

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BIOS

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CONCLUSIONS

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A few months after the conclusion of the Fablearn 2021 International Conference, we can say that the topics addressed are still of great interest to the education community. Even though we talk about technology and didactic innovation, and it is clear how rapidly this is evolving and how difficult it is to keep up with it, especially in the field of education, some topics are still being discussed: coding and educational robotics, makerspaces, STEM and new learning methodologies. Obviously, the focus of research has shifted, and is no longer oriented towards purely technological aspects, since technologies have been extensively covered in recent years. The teachers themselves, thanks to training courses, online resources and many scientific contributions, are better prepared for their use and in many cases have closely followed the setting up of new areas in the school, thanks also to funds made available by Europe.

These were flanked by some reflections on new tools such as Tik tok, or artificial intelligence, as well as a round table on the problem of gender stereotypes at school, attended by university lecturers, researchers and school teachers.

In Italy, the dissemination of technologies to support teaching, and the consequent transformation of educational paradigms, began in 2015 when, with the publication of the National Digital School Plan (PNSD), educational robotics and coding were given a role in schools with respect to supporting the development of skills.

In Italy, the dissemination of technologies to support teaching, and the consequent transformation of educational paradigms, has taken place since 2015 when, with the publication of the National Digital School Plan (PNSD), educational robotics and coding were given a role in schools with respect to supporting the development of skills.

With the implementation of the Creative Ateliers (Ministerial Decree no. 157/2016) and the Key Skills Labs, technologies have also found a specific space for their dissemination: 'Educational scenarios built around robotics and educational electronics, logic and computational thinking, manual and digital artefacts, serious play and storytelling will find their natural home in these spaces' (PNSD, p.50). Still in support of the strengthening of these themes in education, the PNSD reports the MIUR-CINI partnership experience for the promotion of the 'Programme the Future' initiative, as well as an important investment with respect to the so-called STEM disciplines (Science, Technology, Engineering and Mathematics) for which the Ministry promotes educational and financial support actions, aimed at the creation of specific interdisciplinary pathways, since "Enhancing STEM learning is a priority of education systems globally, both to educate students to a broader understanding of the present and to master the scientific and technological tools necessary for the exercise of citizenship, and to improve and increase the skills required by the economy and the world of work. "1 The investment in creative ateliers is a significant step in the introduction of innovative teaching methodologies at school, as they were created precisely to rethink laboratories as places of innovation and creativity, bringing laboratory teaching back to the center, as an essential meeting point between knowledge and know-how, between the student and his or her area of reference.

In 2018, with the updating of the 2012 National Directions, National Directions New Scenarios (National Scientific Committee for the National Directions for the Curriculum for Preschool and First Cycle Education), computational thinking officially becomes a transversal skill to be acquired, an important element in the formation of a young mind, since it enables those mental processes that lead to finding logical and repeatable solutions to problems of various kinds.

The acquisition of problem-solving skills does not necessarily pass through the use of technologies, but can also take place through 'unplugged' activities, since any situation that presupposes the search for a solution strategy, a sequence of actions (procedure or algorithm) to be constructed, a network of connections to be established, enables computational thinking, provided that the actions taken are the consequence of a metacognitive process, i.e. they are not the result of mere random attempts aimed at solving the problem without any stringent planning or logic underneath.

The presentation of papers at the conference certainly showed a focus on STEM disciplines and consequently on the implementation of interdisciplinary projects.

The methodological current that forms the backdrop to all the papers presented at this conference is certainly constructionism (Papert, 1986; Harel, Papert 1991), which takes up the same principles as constructivism (student at the center of his or her own learning process, teacher in the role of facilitator, creation of artefacts) but transforms the objects of interest from theoretical and hypothetical to real objects that can be monolayered, constructed and even revised and modified. This is also supported by the concept of 'Concrete Thinking' of Piagetian origin, as learning is most effective when it is not only mental, but supported by real construction. Papert, in fact, states that thanks to technology, it is possible to make concrete a hitherto merely formal thought: 'From this perspective, it is not just another powerful training tool. It is unique in providing us with the means to pursue what Piaget and many others see as an obstacle to be overcome in the transition from puberty to adult thinking. I believe it allows us to shift the boundary between the concrete and the formal. Knowledge that was only accessible through formal processes can now be approached concretely≫ (Papert, 1984, pp. 17-18).

It is now widespread among teachers who aspire to develop computational thinking in their students, a way of approaching teaching and learning that is inverted with respect to the Gentile tradition: students must be ≪independent, responsible for their own learning≫20 while the teacher must assume the role of guide. Active teaching methodologies for conducting classroom activities therefore become natural when teachers take action to stimulate problem solving or manipulative activities, even more so when these are integrated into the daily routine of their curriculum.

In the "learning by discovery" methodology (Bruner, 1961), as well as in the learning by doing approaches (Dewey, 1938) or in problem-based learning, the traditional teaching method changes: the pupil is the creator of his own learning process, which he carries out in collaboration with his classmates and partly through autonomous study, under the supervision of the teacher who has the function of facilitator in this case. The problems that are proposed to the students are real and involve phases of observation, reflection, analysis and problem modelling on the part of the students in order to then find a solution that is not necessarily unambiguous. It is the path the student takes to reach the objective that gives educational value to the activity. And on this path the student will necessarily encounter obstacles and will be faced with failure as well as error: when the result is not as expected or does not act in the required manner, the student is called upon to reflect on the reasons for the anomalous behaviour and then to re-evaluate his observations and implementations so as to arrive at a correct solution.

The error in this context should not translate into a negative judgement from a scholastic point of view but, should act as a stimulus for the student by helping him to approach knowledge.

The panorama that the articles presented offer us is therefore extremely rich in initiatives, interdisciplinary projects carried out in curricular teaching, inclusion and overcoming stereotypes. A breath of fresh air that serves to show how all this is possible and achievable by anyone with even a minimal technological background and a great desire to get involved with their students.

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